

Blister Agents

Nitrogen Mustard (HN-1) (C₆H₁₃Cl₂N) CAS 538-07-8, UN 2810;

Nitrogen Mustard (HN-2) (C₅H₁₁Cl₂N) CAS 51-75-2, UN 2927;

and

Nitrogen Mustard (HN-3) (C₆H₁₂Cl₃N) CAS 555-77-1, UN 2810

Synonyms:

HN-1: Bis(2-chloroethyl)ethylamine; 2-chloro-N-(2-chloroethyl)-N-ethylethanamine; 2,2'-dichlorotriethylamine; ethylbis(2-chloroethyl)amine; ethyl-S

HN-2: MBA; mechloroethamine; mustine; 2,2'-dichloro-N-methyldiethylamine; dichloren; caryolysin; mechloroethanamine; chlormethine; bis(2-chloroethyl)methylamine

HN-3: Tris(2-chloroethyl)amine; 2-chloro-N,N-bis(2-chloroethyl)ethanamine; 2,2',2''-trichlorotriethylamine

People whose skin or clothing is contaminated with nitrogen mustard can contaminate rescuers by direct contact or through off-gassing vapor.

- **Nitrogen mustards are colorless to yellow, oily liquids with variable odors.**
- **Nitrogen mustards are absorbed by the skin causing erythema and blisters. Ocular exposure to these agents may cause incapacitating injury to the cornea and conjunctiva. When inhaled, nitrogen mustard damages the respiratory tract epithelium and may cause death.**

Description

Nitrogen mustards are vesicants and alkylating agents. They are colorless to pale yellow, oily liquids that evaporate slowly. HN-1 has a faint, fishy or musty odor. It is sparingly soluble in water but miscible with acetone and other organic solvents. At temperatures greater than 194 °C, it decomposes.

HN-2 has a fruity odor at high concentrations and a soapy odor at low concentrations. Its solubility is similar to HN-1.

HN-3 is odorless when pure but has been reported to have a butter almond odor. It is the most stable of the nitrogen mustards but decomposes at temperatures greater than 256 °C. It has a much lower vapor pressure than HN-1 or HN-2 and is insoluble in water.

Routes of Exposure

Inhalation

Inhalation is an important route of exposure. Nitrogen mustard vapors are heavier than air. The LC₅₀ (the product of concentration times time that is lethal to 50% of the exposed

population by inhalation) is approximately 1,500 mg-min/m³ for HN-1 and HN-3, and 3,000 mg-min/m³ for HN-2.

Skin/Eye Contact

Exposure to nitrogen mustard vapor can cause injury to the eyes, skin, and mucous membranes at low concentrations. Direct contact with the liquid can cause skin and eye burns. The median incapacitating dose for the eyes is 100 mg-min/m³ for HN-2 and 200 mg-min/m³ for HN-1 and HN-3. Absorption may occur after skin or eye exposure to liquid or vapor nitrogen mustard and may cause systemic toxicity.

Ingestion

Ingestion is an uncommon route for exposure but can lead to local effects such as esophageal or gastrointestinal burns and systemic absorption.

Sources/Uses

Nitrogen mustards were first developed in the late 1920s and early 1930s. HN-1 was originally designed to remove warts but was later identified as a potential chemical warfare agent; HN-2 was designed as a military agent but was later used in chemotherapy; HN-3 was developed as a military agent. None of the nitrogen mustards have been used on the battlefield, and none are included in U.S. stockpiles.

Standards and Guidelines

HN-1: Airborne Exposure Limit (as recommended by the Surgeon General's Working Group, U.S. Department of Health and Human Services) = 0.003 mg/m³ as a time-weighted average (TWA) for the workplace. No standards exist for HN-2 or HN-3.

Physical Properties

Table 1. Physical Properties of Nitrogen Mustards (Blister Agents)

Property			
	HN-1	HN-2	HN-3
Description	Colorless to pale yellow oily liquid	Pale amber to yellow oily liquid	Colorless to pale yellow oily liquid
Warning properties	Faint fishy or musty odor	Faint soapy odor at low concentrations; fruity odor at high concentrations	Faint butter almond odor
Molecular weight	170.08 daltons	156.07 daltons	204.54 daltons
Boiling point	(760 mm Hg) = 381 °F (194 °C)	(760 mm Hg) = 167 °F (75 °C)	(760 mm Hg) = 493 °F (256 °C) (decomposes)
Freezing point	29.2 °F (-34 °C)	-85 to -76 °F (-65 to -60 °C)	25.3 °F (-3.7 °C)
Specific gravity	No data (water = 1.0)	No data (water = 1.0)	No data (water = 1.0)
Vapor pressure	0.25 mm Hg at 77 °F (25 °C)	0.427 mm Hg at 77 °F (25 °C)	0.0109 mm Hg at 77 °F (25 °C)
Vapor density	5.9 (air = 1.0)	5.4 (air = 1.0)	7.1 (air = 1.0)
Liquid density	1.09 g/mL at 77 °F (25 °C)	1.15 g/mL at 68 °F (20 °C)	1.24 g/mL at 77 °F (25 °C)
Solubility in water	Sparingly soluble	Sparingly soluble	Practically insoluble
Volatility	No immediate danger of fire or explosion	No immediate danger of fire or explosion; however, polymerization results in components which present an explosion hazard in open air.	No immediate danger of fire or explosion; however, polymerization results in components which present an explosion hazard in open air
NAERG#	153	153	153

Incompatibilities

HN-1 is corrosive to ferrous alloys at temperatures of 149 °F (68 °C) and higher. HN-2 and HN-3 do not have any incompatible actions on metals or other materials.

Health Effects

Nitrogen mustards are vesicants causing skin, eye, and respiratory tract injury. Although these agents cause cellular changes within several minutes of contact, the onset of pain and other clinical effects is delayed for hours.

Nitrogen mustards are alkylating agents that may cause bone marrow suppression and neurologic toxicity.

Acute Exposure

Nitrogen mustards are vesicants and alkylating agents; however, the mechanisms of action are not clearly understood. They are highly reactive and combine rapidly with proteins, DNA, or other molecules. Therefore, within minutes following exposure intact mustard or its reactive metabolites are not found in tissue or biological fluids.

CNS

High doses of nitrogen mustards have caused tremors, seizures, incoordination, ataxia, and coma in laboratory animals.

Respiratory

Damage to the mucosa of the airways begins within hours and may progress over several days. Nasal and sinus pain or discomfort, pharyngitis, laryngitis, cough, and dyspnea may occur. Pulmonary edema is uncommon.

Gastrointestinal

Ingestion may cause chemical burns of the GI tract and hemorrhagic diarrhea. Nausea and vomiting may occur following ingestion, dermal, or inhalation exposure.

Ocular

Exposure to nitrogen mustard vapor or liquid may cause intense conjunctival and scleral inflammation, pain, swelling, lacrimation, photophobia, and corneal damage. High concentrations can cause burns and blindness.

Dermal

Direct skin exposure to nitrogen mustards causes erythema and blistering. Generally, a rash will develop within several hours, followed by blistering within 6 to 12 hours. Prolonged contact, or short contact with large amounts, may result in second- and third-degree chemical burns.

Hematopoietic

Systemic absorption of nitrogen mustard may induce bone marrow suppression and an increased risk for fatal complicating infections, hemorrhage, and anemia.

Delayed Effects

Chemotherapeutic doses of HN-2 have been associated with menstrual irregularities, alopecia, hearing loss, tinnitus, jaundice,

impaired spermatogenesis, generalized swelling, and hyperpigmentation.

Potential Sequelae

Chronic respiratory and eye conditions may persist following exposure to large amounts of nitrogen mustards. Narrowing of the esophagus and severe corrosive damage to the stomach lining can result from ingesting formalin.

Chronic Exposure

In laboratory animal studies, prolonged or repeated exposures to nitrogen mustards have caused cancer, developmental and reproductive effects, and hepatic toxicity. Repeated exposures result in cumulative effects because mustards are not naturally detoxified by the body.

Carcinogenicity

The International Agency for Research on Cancer (IARC) has classified nitrogen mustard as probably carcinogenic to humans (Group 2A). There is some evidence that it causes leukemia in humans, and it has been shown to cause leukemia and cancers of the lung, liver, uterus, and large intestine in animals.

Reproductive and Developmental Effects

Nitrogen mustards may decrease fertility. A few case reports have linked treatment with HN-2 to fetal abnormalities in humans. Nitrogen mustards have produced developmental effects in animals.

Prehospital Management

Victims whose skin or clothing is contaminated with liquid nitrogen mustard can contaminate rescuers by direct contact or through off-gassing vapor.

Nitrogen mustards are extremely toxic and may damage the eyes, skin, and respiratory tract and suppress the immune system. Although these agents cause cellular changes within minutes of contact, the onset of pain and other symptoms is delayed.

There is no antidote for nitrogen mustard toxicity. Decontamination of all potentially exposed areas within minutes after exposure is the only effective means of decreasing tissue damage.

Hot Zone

Rescuers should be trained and appropriately attired before entering the Hot Zone. If the proper equipment is not available, or if the rescuers have not been trained in its use, call for assistance from the U.S. Soldier and Biological Chemical Command–Edgewood Research Development and Engineering Center (from 0700-1630 EST call 410-671-4411, and from 1630-0700 EST call 410-278-5201; ask for the Staff Duty Officer).

Rescuer Protection

Nitrogen mustard vapor and liquid are readily absorbed by inhalation and ocular and dermal contact.

Respiratory Protection: Pressure-demand, self-contained breathing apparatus (SCBA) is recommended in response situations that involve exposure to any amount of nitrogen mustard.

Skin/Ocular Protection: Personal protective equipment (PPE) and butyl rubber chemical protective gloves are recommended at all times when these chemicals are suspected to be involved.

Multi-Casualty Triage

Chemical casualty triage is based on walking feasibility, respiratory status, age, and additional conventional injuries. The triage officer must know the natural course of a given injury, the medical resources immediately available, the current and likely casualty flow, and the medical evacuation capabilities. General principles of triage for chemical exposures are presented in the box on the following page. There are four triage categories: immediate (priority 1), delayed (priority 2), minimal (priority 3), and expectant (priority 4).

Before transport, all casualties must be decontaminated. If needed, consult with the base station physician or the regional poison control center for advice concerning management of multiple casualties.

Because most signs and symptoms of nitrogen mustard exposure do not occur for several hours postexposure, patients should be observed for at least 6 hours or sent home with instructions to return immediately if symptoms develop. Patients who develop significant dermal, ocular, or airway injury and patients who have ingested nitrogen mustard should be transported to a medical facility for evaluation.

Symptoms may not develop for 24 hours. Patients with mild symptoms who are seen long enough after exposure to minimize the likelihood that the lesions will worsen may be sent home after their names, addresses, and telephone numbers have been recorded. They should be advised to rest and to seek medical care promptly if additional symptoms develop (see *Follow-up Instructions* included with the *Nitrogen Mustard Patient Information Sheet*).

Consult with the base station physician or closest Metropolitan Medical Response System, or the regional poison control center for advice regarding triage of multiple victims.

General principles of triage for chemical exposures are as follows:

- (1) Check triage tag/card for any previous treatment or triage.
- (2) Survey for evidence of associated traumatic/blast injuries.
- (3) Observe for sweating, labored breathing, coughing/vomiting, secretions.
- (4) Severe casualty triaged as immediate if assisted breathing is required.
- (5) Blast injuries or other trauma, where there is question whether there is chemical exposure, victims must be tagged as immediate in most cases. Blast victims evidence delayed effects such as ARDS, etc.
- (6) Mild/moderate casualty: self/buddy aid, triaged as delayed or minimal and release is based on strict follow up and instructions.
- (7) If there are chemical exposure situations which may cause delayed but serious signs and symptoms, then overtriage is considered appropriate to the proper facilities that can observe and manage any delayed onset symptoms. *For nitrogen mustards, potentially exposed individuals should be observed for 6 - 8 hours and, if signs or symptoms appear, be sent to the hospital.*
- (8) Expectant categories in multi-casualty events are those victims who have experienced a cardiac arrest, respiratory arrest, or continued seizures immediately. Resources should not be expended on these casualties if there are large numbers of casualties requiring care and transport with minimal or scant resources available.

1. *Immediate*: casualties who require lifesaving care within a short time, when that care is available and of short duration. This care may be a procedure that can be done within minutes at an emergency treatment station (e.g., relief of an airway obstruction, administering antidotes) or may be acute lifesaving surgery.
2. *Delayed*: casualties with severe injuries who are in need of major or prolonged surgery or other care and who will require hospitalization, but delay of this care will not adversely affect the outcome of the injury (e.g., fixation of a stable fracture).
3. *Minimal*: casualties who have minor injuries, can be helped by nonphysician medical personnel, and will not require hospitalization.
4. *Expectant*: casualties with severe life-threatening injuries who would not survive with optimal medical care, or casualties whose injuries are so severe that their chance of survival does not justify expenditure of limited resources. As circumstances permit, casualties in this category may be reexamined and possibly be retriaged to a higher

ABC Reminders

Quickly ensure that the victim has a patent airway. Maintain adequate circulation. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Apply direct pressure to stop arterial bleeding, if present.

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.

Decontamination Zone

Decontamination within 1 or 2 minutes following exposure is the only effective means for decreasing tissue damage. Later decontamination is not likely to improve the victim's condition but will protect other personnel from exposure. Decontaminable gurneys and back boards should be used if available when managing casualties in a contaminated area. Decontaminable gurneys are made of a monofilament polypropylene fabric that allows drainage of liquids, does not absorb chemical agents, and is easily decontaminated. Fiberglass back boards have been developed specifically for use in HAZMAT incidents. These are nonpermeable and readily decontaminated. The **Chemical Resuscitation Device** is a bag-valve mask equipped with a chemical agent cannister that can be used to ventilate casualties in a contaminated environment.

Rescuer Protection

Personnel should continue to wear the same level of protection as required in the Hot Zone (see *Rescuer Protection* under *Hot Zone*, above).

ABC Reminders

Quickly ensure that the victim has a patent airway. Maintain adequate circulation. Stabilize the cervical spine with a decontaminable collar and a backboard if trauma is suspected. Administer supplemental oxygen if cardiopulmonary compromise is suspected. Assist ventilation with a bag-valve-mask device equipped with a cannister or air filter if necessary. Direct pressure should be applied to control heavy bleeding, if present.

Basic Decontamination

The eyes and skin must be decontaminated within 1 or 2 minutes after exposure to reduce tissue damage. Flush the eyes immediately with water for about 5 to 10 minutes by tilting the head to the side, pulling eyelids apart with fingers, and pouring water slowly into eyes. Do not cover eyes with bandages.

If exposure to liquid agent is suspected, cut and remove all clothing and wash skin immediately with soap and water. If shower areas are available, showering with water alone will be adequate. However, in those cases where water is in short supply, and showers are not available, an alternative form of decontamination is to use 0.5% sodium hypochlorite solution or absorbent powders such as flour, talcum powder, or Fuller's earth. If exposure to vapor only is certain, remove outer clothing and wash exposed areas with soap and water or 0.5% solution of sodium hypochlorite. Place contaminated clothes and personal belongings in a sealed double bag.

In cases of ingestion, **do not induce emesis**. There is no evidence that administration of activated charcoal is beneficial.

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 pose no serious risk of secondary contamination to rescuers. In such cases, Support Zone personnel require no specialized protective gear.

ABC Reminders

Quickly ensure that the victim has a patent airway. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Ensure adequate respiration; administer supplemental oxygen if cardiopulmonary compromise is suspected. Maintain adequate circulation. Establish intravenous access if necessary. Attach a cardiac monitor, as needed. Direct pressure should be applied to stop bleeding, if present.

Additional Decontamination

In cases of ingestion, **do not induce** emesis. If the victim is alert and able to swallow, give 4 to 8 ounces of milk or water to drink. There is no evidence that administration of activated charcoal is beneficial.

Advanced Treatment

Intubate the trachea in cases of respiratory compromise. When the patient's condition precludes endotracheal intubation, perform cricothyrotomy if equipped and trained to do so.

Treat patients who have bronchospasm with bronchodilators. Trauma patients who are comatose, hypotensive, or have seizures or cardiac dysrhythmias should be treated according to advanced life support (ALS) protocols.

Transport to Medical Facility

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

Emergency Department Management

Patients whose skin or clothing is contaminated with liquid nitrogen mustard can contaminate rescuers by direct contact or through off-gassing vapor.

Nitrogen mustards are extremely toxic and may damage eyes, skin, and respiratory tract and suppress the immune system. Although these agents cause cellular changes within minutes of contact, the onset of pain and other symptoms is delayed. Thus, patients arriving immediately from the scene of exposure are not likely to have signs and symptoms.

There is no antidote for nitrogen mustard toxicity. Decontamination of all potentially exposed areas within minutes after exposure is the only effective means of decreasing tissue damage. Thus, by the time a patient arrives in the emergency department, decontamination can only prevent secondary exposure to medical staff; it does not limit the patient's injury. Medical treatment is supportive.

Decontamination Area

Previously decontaminated patients may be treated or held for observation. Others require decontamination as described below.

ABC Reminders

Evaluate and support the airway, breathing, and circulation. Intubate the trachea in cases of respiratory compromise. If the patient's condition precludes intubation, surgically create an airway.

Treat patients who have bronchospasm with bronchodilators. Patients who are comatose or hypotensive, or who have seizures or ventricular dysrhythmias due to other exposures or trauma, should be treated in the conventional manner.

Personal Protection

If contaminated patients are expected to arrive at the Emergency Department, they must be decontaminated before being allowed to enter the facility. Decontamination can take place inside the hospital only if there is a decontamination facility with negative air pressure and floor drains to contain contamination. Personnel should wear the same level of protection required in the Hot Zone (see *Rescuer Protection* under Hot Zone, above).

Basic Decontamination

Flush the eyes with water for about 5 to 10 minutes. Do not cover eyes with bandages; if necessary, use dark or opaque goggles to relieve discomfort from photophobia.

If a liquid splash is suspected, clothing must be removed and the patient showered using soap and water. Showering should be

accomplished using cool water and enough water pressure to quickly reduce the potential for agent penetration of the skin. If the patient was exposed to vapor only, remove outer clothing and wash exposed skin with soap and water. Place contaminated clothes and personal belongings in a sealed double bag.

In cases of ingestion, **do not induce emesis**. If the victim is alert and able to swallow, give 4 to 8 ounces of milk or water to drink if not already administered. There is no evidence that administration of activated charcoal is beneficial.

Critical Care Area

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

ABC Reminders

Evaluate and support the airway, breathing, and circulation (as in *ABC Reminders*, above). Establish intravenous access and continuously monitor cardiac rhythm in seriously ill patients.

Patients who are comatose, hypotensive, or who have seizures or ventricular dysrhythmias due to other exposures or trauma should be treated in the conventional manner.

Triage

Patients arriving at the emergency department directly from the scene of potential exposure (within 30-60 minutes) will rarely have symptoms. Following decontamination, patients with signs of airway involvement should be admitted directly to the Critical Care Unit. The others should be observed for at least 6 hours. Patients arriving later should be evaluated as described below. **The sooner after exposure that symptoms occur, the more likely they are to progress and become severe.**

Eye Exposure

Mild conjunctivitis beginning more than 12 hours after exposure is unlikely to progress to a severe lesion. The patient should have a thorough eye examination (including a test for visual acuity). The patient should be treated with a soothing eye solution, sent home, and told to return if there is worsening. Conjunctivitis beginning earlier and other effects such as lid swelling and signs/symptoms of inflammation indicate a need for inpatient care and observation.

Skin Exposure

A small area of erythema beginning later than 12 hours after exposure is unlikely to progress to a significant lesion. The patient should be examined, treated with a soothing lotion, sent home, and instructed to return if progression occurs. A patient with a significant area of erythema or one seen earlier with a

significant area of erythema with or without blistering should be admitted for further evaluation.

Airway Exposure

A patient with a mild, non-productive cough, irritation of the nose and sinuses, and/or a sore throat that began later than 12 hours after exposure should be told to use a cool steam vaporizer and lozenges or cough drops, and sent home with instructions to return if the symptoms worsen. Patients with more severe effects (laryngitis, shortness of breath, a productive cough) seen at any time postexposure should be admitted directly to the Critical Care Unit once decontamination has been assured. Those with less severe effects should be admitted to a routine care ward.

Ingestion Exposure

Do not induce emesis. If a large dose has been ingested and the patient's condition is evaluated within 30 minutes after ingestion, cautious orogastric lavage might remove ingested material. However, the risk of potential bleeding and perforation must be considered. There is no evidence that activated charcoal is beneficial.

*Antidotes and
Other Treatments*

There is no antidote for nitrogen mustard. Treatment is supportive.

Laboratory Tests

Routine laboratory studies should be done for all patients requiring admission. These include CBC, glucose, and serum electrolytes. Chest x-ray and pulse oximetry (or ABG measurements) are recommended for inhalation exposures.

Disposition

As discussed above, consider hospitalizing patients who have had significant exposures.

Delayed Effects

Significant systemic absorption of nitrogen mustard may produce a fall in the leukocyte count beginning on days 3 to 5. Erythrocytes and thrombocytes may subsequently fall if bone marrow damage is severe and in this case the risk of life-threatening infection rises.

Patient Release

Patients who have sustained mild exposure may be discharged. Discharged patients should be advised to rest and to seek medical care promptly if symptoms develop (see page 22, *Follow-up Instructions*, included with the *Nitrogen Mustard Patient Information Sheet*).

Reporting

Other people may still be at risk in the setting where this incident occurred or away from the setting due to secondary contamination. If a public health risk exists, notify your state or local health department or other responsible public agency.

General Medical Management

Since there are no immediate effects from mustard, most patients will go home or elsewhere from the incident and present to a medical facility hours later when effects occur. These patients must not be allowed to enter the facility until they have been decontaminated.

Patients whose skin or clothing is contaminated with liquid nitrogen mustard can contaminate medical personnel and others by direct contact or through off-gassing vapor.

Nitrogen mustards are extremely toxic and may damage the eyes, skin, and respiratory tract and suppress the immune system. Although these agents cause cellular changes within minutes of contact, the onset of pain and other symptoms is delayed.

There is no antidote for nitrogen mustard toxicity. Medical treatment is supportive.

Decontamination Area

A patient who arrives at a general medical facility (non-emergency) probably will not have undergone decontamination. Such a patient must be decontaminated as described below before being allowed to enter the facility.

ABC Reminders

Patients may have other injuries and must be evaluated using the concepts of BLS and ALS.

Personal Protection

Medical personnel or others (e.g., HAZMAT personnel) must meet incoming patients outside the facility or, if available, in the facility's decontamination area. Decontamination can take place inside the medical facility only if there is a decontamination area with negative air pressure and floor drains to contain contamination. Personnel must wear protection required in the Hot Zone (see *Rescuer Protection* under Hot Zone, above).

Basic Decontamination

A patient who has arrived directly from the scene must be decontaminated before being admitted to the facility. If a liquid splash is suspected, clothing must be removed and the patient showered using soap and water. If the patient was exposed to vapor only, removal of outer clothing and flushing of exposed skin (face, hair, and arms/hands) with soap and water or water alone is adequate. Place contaminated clothes and personal belongings in a sealed double bag.

A patient who has gone home and bathed and changed clothes may be considered decontaminated; however, the home will

require decontamination. Otherwise, patients should undergo the decontamination procedures described above.

Initial Evaluation

Patients arriving at the medical facility directly from the scene of potential exposure (within 30–60 minutes) will rarely have signs and symptoms. Patients with signs of airway involvement should be admitted directly to the Critical Care Unit once decontamination has been assured. The others should be observed for at least 6 hours.

Patients arriving later should be evaluated as described below. The sooner after exposure signs and symptoms occur, the more likely they are to progress and become severe.

Eye Exposure

Mild conjunctivitis beginning more than 12 hours after exposure is unlikely to progress to a severe lesion. The patient should have a thorough eye examination (including a test for visual acuity). The patient should be treated with a soothing eye solution, such as Visine or Murine, sent home, and told to return if there is worsening. Conjunctivitis beginning earlier and other effects such as lid swelling and signs/symptoms of inflammation indicate admission.

Skin Exposure

A small area of erythema beginning later than 12 hours after exposure is unlikely to progress to a significant lesion. The patient should be examined, treated with a soothing lotion, sent home, and instructed to return if progression occurs. A patient with a significant area of erythema or one seen earlier with a significant area of erythema with or without blistering should be admitted for further evaluation.

Airway Exposure

A patient with a mild, non-productive cough, irritation of the nose and sinuses, and/or a sore throat that began later than 12 hours after exposure should be told to use a cool steam vaporizer and lozenges or cough drops and sent home with instructions to return if the symptoms worsen. Patients with more severe effects (laryngitis, shortness of breath, a productive cough, pseudomembrane formation) seen at any time postexposure should be admitted directly to the Critical Care Unit once decontamination has been assured. Those with less severe effects should be admitted to a routine care ward.

Ingestion Exposure

Do not induce emesis. If a large dose has been ingested and the patient's condition is evaluated within 30 minutes after ingestion, cautious orogastric lavage might remove ingested material. However, the risk of potential bleeding and perforation must be

considered. There is no evidence that activated charcoal is beneficial.

Medical Management

General

There is no antidote for nitrogen mustard. Management is supportive.

A guideline is to keep the wounds (skin, eye, airway) free from infection. A patient with severe skin burns may require care in a burn unit.

Skin Exposure

Most burns are second degree although third degree burns may occur after liquid exposure. In general, small blisters (i.e., <1 cm) should remain roofed and larger ones (>1 cm) should be unroofed. This is a controversial issue, but many feel that the roof will eventually come off anyway. Blister fluid does not contain mustard or other toxic substances. The denuded area should be irrigated two or three times a day using a whirlpool if the lesion is large (the patient should be given ample amounts of a systemic analgesic beforehand). This should be followed by liberal application of a topical antibiotic. Skin lesions may take many months to heal. Fluids are not lost as they are in thermal burns, and fluid replacement should be according to the general needs of the patient and not according to "burn therapy" formulas. Systemic antibiotics should be used when there are signs of infection and a culture indicates the responsible organism. Patients with a large area of second or third degree burns should be transferred to a Burn Unit for further care and reverse isolation.

Eye Exposure

Eye lesions range from conjunctivitis to involvement of the entire eye including cornea and lids. Erosion of or perforation of the cornea may occur with very severe exposure to liquid, but this is rare. Readily available eye solutions may suffice for conjunctivitis. More severe lesions should be treated with a topical mydriatic (e.g., atropine), topical antibiotics, and vaseline or similar substance applied to the lid edges several times a day. Topical analgesics may be used only for an initial examination (including slit lamp and a test of visual acuity), but not after. Pain should be controlled with systemic analgesics. Once the lid edema and blepharospasm subside and the eyes are open, dark glasses may reduce the discomfort of photophobia. Some authorities feel that topical steroids (used within the first 24 hours only) may reduce inflammation.

Inhalation Exposure

Airway damage may range from irritation of the nose and sinuses, to pharyngitis, to destruction of the airway mucosa from the upper airways to the smallest bronchiole. Airway damage is a common cause of death. Upper airway irritation (nose, sinuses, pharynx) may benefit from cool steam inhalation and cough drops or throat lozenges. A patient with signs of airway damage below the pharynx should be provided with oxygen, assisted ventilation as necessary (with PEEP); at the first sign of damage of the larynx or below, the patient should be intubated and transferred to the Critical Care Unit. Bronchodilators should be used if there are signs of bronchoconstriction; steroids might be used if the usual bronchodilators are not effective, but otherwise steroids are not of proven value. Daily sputum cultures should be done and systemic antibiotics should be begun with signs of infection and an identified organism. A chemical pneumonitis may occur in the first several days with infiltrates on X-ray, an increase in WBC, and a fever, but this is generally sterile. Organisms generally are not the cause until the third or fourth day postexposure, and antibiotics should not be used prophylactically. Patients with airway damage below the pharynx should be managed on the Critical Care Unit by a physician experienced in the management of complicated pulmonary and airway injuries.

Bone Marrow

If the bone marrow has been damaged, the white blood cell count in the peripheral blood will start to decrease at about days 3 to 5 after exposure. This decrease may be followed by a decrease in red blood cells and platelets. Often, this decrease is not marked and the marrow recovers. Transfusions may be useful. Treatment with granulocyte colony-stimulating factor (GCSF) has been successful experimentally with nitrogen mustard. Marrow transplants have not been attempted, but might be useful. A patient with a marked decrease in white blood cell count should be transferred to an Oncology or Burn Unit for reverse isolation.

Laboratory Evaluation

Routine laboratory studies for admitted patients include glucose, serum electrolytes, and daily CBC. Chest X-ray and pulse oximetry (or ABG measurement) should be done frequently on all patients with inhalation exposure.

**Disposition and
Follow-up**

Patients with moderate to severe exposures will require hospitalization, as described above.

Patient Release

Patients who have sustained mild exposure may be discharged. Discharged patients should be advised to rest and to seek medical

care promptly if symptoms develop (see below, *Follow-up Instructions*, included with the *Nitrogen Mustard Patient Information Sheet*).

Follow-up

Follow-up evaluation of respiratory, neurological, and bone marrow function should be arranged for severely exposed patients.

Reporting

Other people may still be at risk in the setting where this incident occurred or away from the setting due to secondary contamination. If a public health risk exists, notify your state or local health department or other responsible public agency.

Blister Agents
Nitrogen Mustard (HN-1, HN-2, and HN-3)
Patient Information Sheet

This handout provides information and follow-up instructions for people who have been exposed to nitrogen mustards.

What are nitrogen mustards?

Nitrogen mustards are compounds that were initially developed as chemical warfare agents or pharmaceuticals. They have never been used on the battlefield. HN-2 has been used in chemotherapy.

What immediate health effects can be caused by exposure to nitrogen mustards?

Nitrogen mustards cause injury to the skin, eyes, nose and throat. Eye damage may occur within minutes of exposure. Nausea and vomiting also may occur shortly after exposure. Skin rashes, blisters, and lung damage may develop within a few hours of exposure but may take 6 hours or more. Nitrogen mustards can also suppress the immune system.

Can nitrogen mustard poisoning be treated?

There is no antidote for nitrogen mustard, but its effects can be treated and most exposed people recover. Immediate decontamination reduces symptoms. People who have been exposed to large amounts of nitrogen mustard will need to be treated in a hospital.

Are any future health effects likely to occur?

Adverse health effects, such as chronic respiratory diseases, may occur from exposure to high levels of these agents. Severe damage to the eye may be present for a long time following the exposure.

What tests can be done if a person has been exposed to nitrogen mustard?

There are no routine tests to confirm exposure.

Where can more information about nitrogen mustard be found?

More information about nitrogen mustards can be obtained from your regional poison control center; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in toxicology or occupational and environmental health. Ask the person who gave you this form for help 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:

- coughing, wheezing, shortness of breath, or discolored sputum
- increased pain or discharge from injured eyes
- increased redness, pain, or a pus-like discharge from injured skin
- fever or chills

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 _____