Weapons of Mass Destruction: Chemical, Biological, Radiological NBC Agent Descriptions and Treatment Protocols

Treatment protocols described here include drugs and procedures that are administered both by pre-hospital (CEP) personnel and hospital personnel. Thus, some drug administrations and procedures are outside the paramedic scope of practice.

The following treatment protocols have been reviewed by the PFD Medical Director, members of the Board of Directors of Arizona Emergency Medical Services (the regional emergency medical services association for physicians), and Maricopa County Public Health Department Medical Director. Network hospital personnel (physicians) were also consulted in developing and modifying the protocols.

Treatment protocols for radiological/nuclear agents are addressed in Phoenix Regional Department Standard Operating Procedure *M.P. 204.03 Radiological Hazards* and are not included here.

Agents Addressed

- Chlorine
- Hydrocyanic Acid, Hydrogen Cyanide & Cyanogen Chloride
- Methyl Isocyanate, Methylene Bisphenyl Isocyanate & Methylene Dilsocyanate
- Mustard (Sulfur Mustard)
- Nerve Agents

Chlorine

Military Designation**:** CL

Description: Chlorine is found as an amber liquid or greenish-yellow gas with a very characteristic irritating, pungent odor. Chlorine is severely irritating to the skin, eyes, and respiratory tract. Although generally stored as a liquid, when released, the resulting gas is about two times heavier than air.

*Non-Military Uses***:** Chlorine is used widely in industrial settings in the organic synthesis and manufacture of antifreeze agents, solvents, refrigerants, resins, bleaching agents, and other inorganic chemicals. There is an exceptionally wide use of chlorine in non-commercial and home settings as a cleaning agent, bleaching agent, bacteriostatic, and disinfecting agent. Storage of this substance in a variety of liquid and granular forms is widespread.

Treatment Protocol

- General
  - Chlorine is found as a greenish-yellow gas, with a pungent, acrid, characteristic odor. Sensitivity to the odor is below toxic levels; however, since some sensory adaptation occurs, repeat exposures are more likely to produce toxic effects. Exposures irritate eyes and central (upper) airways within minutes. Low doses produce some cough and choking sensation. Moderate doses also produce a sense of suffocation, hoarseness, and substernal pain. High doses also produce a severe dyspnea, with pulmonary edema, nausea, vomiting, headache, syncope also seen. Very high doses may produce sudden death without an obvious pulmonary lesion, possibly via laryngospasm. All recognized exposures should be referred for direct observation/care.
- Patient Evaluation
  - Victims should be immediately removed from the toxic environment by fully masked personnel. Chemical protective clothing is required for liquid/solution exposures.
  - Liquid contamination causes eye and skin burns on contact. Contaminated clothing should be removed/disposed of.
- Treatment
  - Eyes: Liquid exposures should be flushed with copious quantities of water. Gas exposures, if symptomatic, should be flushed with water.
  - Skin: Liquid exposures should be flushed with copious quantities of water; contaminated clothing should be removed/disposed of. Gas exposures require no specific therapy unless symptomatic. Intense gas exposure produces burns; wash with water.
  - Breathing: Evaluate respiration, cyanosis, bronchospasm.
    - If apneic: CPR with intubation. Be aware that laryngospasm may be present with intense exposures, hence intubation may be very difficult, and surgical cricothyrotomy could be required. Medical attention should be sought.
    - If stridorous/hoarse: Consider intubation under direct vision since laryngospasm may be imminent (see above). Medical attention should be sought.

- If dyspnea/cough/chest tightness: Consider intubation for impending pulmonary edema. Also consider possible bronchospasm sufficiently severe to have so little air exchange that wheezes are absent. Medical attention should be sought. Codeine-containing demulcents may help. Be wary of sedation.
- If bronchospasm: Provide aggressive bronchodilation:
  - Adult:
    - Inhaled albuterol: unit dose q 2 hr.
    - Steroids: methyl prednisone, load 120 mg IV, then 60 mg q 6 hr.
    - Theophylline: load 150 mg IV, then 30 mg/hr.
  - Infants and children (0-12 yr):
    - Inhaled albuterol: 0.15 mg/kg per nebulized dose up to 5 mg/20 minutes for first 2 hr.
    - Steroids: methyl prednisone: 1 mg/kg IV q 6 hr.
    - Theophylline: 10 mg/kg IV/24 hr.
  - Elderly:
    - Inhaled albuterol: unit dose q 3 hr.
    - Steroids: methyl prednisone, load 125 mg IV, then 60 mg q 6 hr.
    - Theophylline (occasional use): load 100 mg IV, then 25 mg/hr.
- If asymptomatic: Maintain direct observation for at least 1 hour; if becomes symptomatic, treat as above. If still asymptomatic, continue to recheck every hour for additional 12 hours since some bronchospasm may appear late.
- If hypoxic from bronchospasm, administer bronchodilators and supplemental oxygen. If hypoxic from pulmonary edema: oxygen may be utilized with positive pressure (ventilation after intubation).
- If pulmonary edema occurs: Treat as noncardiac pulmonary edema (Adult Respiratory Distress Syndrome or ARDS) with positive pressure ventilation afterwards. Diuretic therapy is not indicated.
- Inhalation exposures may produce pulmonary infiltrates, fever, and white blood cell elevations leading to an erroneous diagnosis of (presumed bacterial) pneumonia. Prophylactic antibiotics are not indicated. Surveillance bacteriologic cultures are obtained anticipating an approximate 50% risk of nosocomial pneumonia at days 3-6.

- Note**:** The anatomical configuration of infants' and children's airways makes wheezing a less reliable indicator of bronchospasm. Severe small airway constriction with resultant hypoxia may be present. Any apparent infant or child respiratory distress should be immediately assessed with oximetry.

Hydrocyanic Acid, Hydrogen Cyanide and Cyanogen Chloride

Military Designations: AC (hydrocyanic acid) and CK (cyanogen chloride)

*Description***:** Both of these substances are liquids, but they vaporize (evaporate) at about 73/F and 58/C, so they will be in the gaseous form under most temperate conditions. AC has an odor of bitter almonds; CK is pungent. AC vapor is lighter than air, whereas CK gas is heavier than air. Cyanogen chloride is quickly metabolized to cyanide once absorbed into the body and causes the same biological effects as hydrogen cyanide. In addition, CK is irritating to the eyes, nose, and throat (similar to riot control agents), whereas AC is nonirritating.

Non-Military Uses: Large amounts of cyanide (most in the form of salts) are produced, transported, and used by U.S. industry annually. Cyanide is used in fumigation, photography, extraction of metals, electroplating, metal cleaning, tempering of metals, and the synthesis of many compounds. It is released when synthetic fibers and plastics burn.

Treatment Protocol

- General
  - Patient should be removed from the toxic environment immediately.
  - These substances are very volatile, so there is little need for decontamination if exposure was to vapor alone. If liquid was present, remove patient's clothing; wash liquid off skin.
  - The effects of vapor from either form of cyanide appear within seconds to a minute. If patient has no or only mild effects when seen 5 to 30 minutes after exposure, he/she will need no treatment.
  - Severe cyanide poisoning produces metabolic acidosis. If cyanide poisoning is suspected in a patient who does not have moderate or severe acidosis, treatment for cyanide poisoning should not be delayed, but the diagnosis should be reconsidered

- Patient evaluation (Level of consciousness, respiratory rate, heart rate)
    - Exposure to high concentration: transient hyperpnea, followed by convulsions (30 seconds after exposure), gradual decrease in respiratory rate and depth to apnea (3-5 minutes) and cessation of cardiac activity (5-8 minutes).
    - Exposure to lower concentration: flushing, headache, anxiety, agitation, vertigo, feeling of weakness, nausea, muscular trembling (cyanogen chloride may cause irritation of eyes, nose, and airways). Prolonged exposure may lead to effects listed above.
    - Odor of bitter almonds may be detected (half of the population cannot smell this); normal pupils (may be dilated in terminal stage); cherry-red skin (may not be present); diaphoresis; venules in fundus are same color as arterioles; cyanosis occurs only after circulatory collapse and apnea.
- Treatment
    - For a mild exposure (conscious and breathing): observe; no antidotes; oxygen may be given to young or old or in presence of heart disease in a patient with mild symptoms.
    - Severe exposure (unconscious, not breathing): should immediately receive 100% oxygen. Cardiac monitoring and evaluation of oxygen saturation should be done when possible. (Saturation will be normal even in severe casualty until terminal stage; however, additional oxygen may assist in therapy.) Antidotes should be administered as soon as possible (see below). It is important to note that pulse oximeter results are completely unreliable in the setting of methemoglobinemia, which is induced by amyl nitrite or sodium nitrite therapy.
        - For a severe exposure: ventilate using bag-valve-mask with one ampule of amyl nitrite (crushed) in bag; after several minutes, add another (crushed) ampule; keep adding an ampule every several minutes. This is a temporary measure until IV drugs can be given, but it may assist in recovery.
        - Administer 300 mg (10 ml) of sodium nitrite IV over 5 minutes. Flush line. [Children's dose: 0.2-0.3 ml/kg, or 6-9 mg/kg of the 3% solution. No separate recommendation for infants.
        - For elderly, use adult dose unless they are small and frail.] Be aware: Nitrites produce orthostatic hypertension, but a patient who can stand unaided does not need nitrite therapy.

- Follow with 12.5 grams (50 ml) of sodium thiosulphate IV. [Children's dose: 0.4 mg/kg, or 1.65 ml/kg of the 25% solution. No separate recommendation for infants. Adult dose should be used for elderly unless they are small and frail. Use care giving nitrite in a patient with hypertension or heart disease.] (Amyl nitrite, sodium nitrite, and sodium thiosulfate are in the Pasadena (formerly Lilly) Cyanide Antidote Kit, the latter two in ampules of 300 mg/10 ml and 12.5 grams/50 ml. Use one-half dose in 20 minutes if no improvement. See instructions on top of Antidote Kit box.

- If patient continues to remain apneic, intubate and continue oxygen through tube with assisted ventilation.
- Transfer apneic or unconscious patients to medical facility.
- Patients often recover rapidly unless CNS hypoxia has occurred.

Methyl Isocyanate, Methylene, Bisphenyl Isocyanate, and Methylene Dilsocyanate MDI

Military Designations: None

*Description***:** Methylene Bisphenyl Isocyanate (MDI) is found as a solid in white to yellow flakes. Various liquid solutions are used for industrial purposes. There is no odor to the solid or the liquid solutions. The vapor is approximately eight times heavier than air. This chemical is a strong irritant to the eyes, mucus membranes, skin, and respiratory tract. This chemical is also a very potent respiratory sensitizer.

Non-Military Uses: Very large quantities of MDI are produced, transported, and used annually in the United States. Various industrial processes utilize MDI in production and usage of (poly)urethane foams, lacquers, and sealants. MDI is a commonly used precursor in the industrial production of insecticides and laminating materials. Noncommercial uses of polyurethanes such as in isocyanate paints or in cutting of uncured urethanes may also cause exposure. Thermal degradation of these substances may produce MDI as a combustion by-product.

Treatment Protocol

- General
  - MDI is found as a solid, which has a melting point of 37 degrees C. Vapor exposures occur with liquids containing dissolved solid. Gas exposures may occur with high-temperature volatilization. Thermal decomposition produces carbon monoxide and oxides of nitrogen. Sensitivity to this substance (eye, nose irritation) occurs at concentrations five times higher than OSHA limits (0.2 $mglm^3$); hence toxic exposures may go unrecognized.
  - Exposures lead to:
    - Sensitizing effects: Respiratory sensitization may occur, particularly in individuals with known asthma, allergies, or recognized isocyanate sensitivity (e.g., TDI).
    - Irritant effects: Eyes, mucous membranes and skin may be irritated, particularly with prolonged, repetitive, or intense exposures. High concentrations may also produce cough, dyspnea, and lethal pulmonary edema.
- Patient Evaluation
  - Victim should be immediately removed from the toxic environment by personnel in chemically protective clothing. Vapor or gas hazards should be anticipated with full (positive pressure) masks. Liquid/solid contamination should be corrected by clothing removal and soap and water decontamination.
- Treatment
  - Eyes: There is no specific therapy appropriate. Liquid/solid exposures should be irrigated with copious quantities of water. Subsequently, symptomatic individuals should seek medical attention.
  - Skin: There is no specific therapy appropriate. Liquids/solids should be removed with soap and water. Single exposures are unlikely to create rashes unless previously sensitized. Intense exposure may produce a dermatitis and require referral.
  - Swallowing: Liquids/solids should be removed by induced vomiting in the conscious victim or by lavage otherwise.
  - Breathing: Symptoms due to sensitivity may be delayed up to 8 hr after exposure. Respiratory symptoms may appear with skin, ocular or GI exposure in previously sensitized individual.
    - If apneic: CPR, may require intubation for pulmonary edema. Consider severe bronchospasm in previously sensitized victim.
    - If stridorous/hoarse: Consider intubation under direct vision.

- If dyspnea/cough/chest tightness: Consider intubation for impending pulmonary edema. Also consider possible bronchospasm sufficiently severe to have so little air exchange that wheezes are absent. Medical attention should be sought. Codeine-containing demulcents may help. Be wary of sedation.
- *Note*: The anatomical configuration of infants' and children's airways makes wheezing a less reliable indicator of bronchospasm. Severe smaller airway constriction with resultant hypoxia may be present. Any apparent infant or child respiratory distress should be immediately assessed with oximetry.
- If bronchospasm: Treat as asthma with inhaled albuterol. Bronchospasm may be particularly severe, especially in previously sensitized individuals.

o Treat aggressively:
  - Adults:
    - Inhaled albuterol: unit dose q 2 hr or continuous neb 15 g/hr.
    - Steroids: methylprednisolone load 250 mg IV, then 80 mg q 6 hr.
    - Theophylline: load 150 mg IV, then 30 mg/hr.
  - Infants and children (0-12 yr.):
    - Inhaled albuterol: 0.15 mg/kg per nebulized dose up to 5 mg/20 minutes for first 2 hr.
    - Steroids: methylprednisolone; 1 mg/kg q 6 hr.
    - Theophylline: 10 mg/kg IV/24 hr.
  - Elderly:
    - Inhaled albuterol: unit dose q 3 hr.
    - Steroids: methylprednisolone load 125 mg IV, then 60 mg q 6 hr.
    - Theophylline (occasional use): load 100 mg IV then 25 mg/hr.

o Upper airway obstruction: This is very rarely seen and only with intense exposures. Hoarseness and stridor suggest impending laryngospasm; consider intubation under direct vision.
  - If pulmonary edema (may rarely occur with intense exposures): Treat as non-cardiac pulmonary edema (Adult Respiratory Distress Syndrome or ARDS see PHOSGENE).
  - If hypoxia (commonly from bronchospasm, rarely from pulmonary edema): Treat with above bronchodilation and oxygen.
  - If cough: Codeine-containing demulcents (tissue-soothing agents) may help. Be wary of sedation.

Mustard (Sulfur Mustard)

Military Designations: H; HD; HS

*Description***:** Mustard is a "blister agent" that causes cell damage and destruction. It is a colorless to light yellow to dark brown oily liquid with the odor of garlic, onion, or mustard. It does not evaporate readily but may pose a vapor hazard in warm weather. It is a vapor and liquid hazard to skin and eyes, and a vapor hazard to airways. Its vapor is five times heavier than air.

Non-Military Uses: Sulfur mustard has been used as a research tool to study DNA damage and repair. A related compound, nitrogen mustard, was the first cancer chemotherapeutic agent and is still used for some purposes.

Treatment Protocol

- General
  - Mustard causes no immediate effects. The initial clinical effects of mustard (which usually involve the eyes, the skin, and the airways) appear 2 to 24 hours (usually 4 to 8 hours) after exposure to liquid mustard or to mustard vapor. However, liquid or vapor mustard penetrates the skin and mucous membranes and damages cells within minutes of exposure, so decontamination must be done immediately after exposure.
  - The patient should be immediately removed from the toxic environment.
  - If liquid contact, clothing should be removed, and skin decontaminated with soap and cool water, or thoroughly flushed with water alone. Eyes should be flushed with large amounts of saline. If exposure is to vapor alone, remove clothing.
  - If there is a history of definite exposure, patient should be taken to medical facility for observation.
- Patient evaluation: Initial effects (usually 2 to 24 hours after exposure)
  - Eyes: irritation, feeling of grit in eye, redness.
  - Skin: erythema (will progress to blisters 1 to 4 hours later if exposure was large).
  - Airways: irritation of nose, voice change, sinus pain, hacking cough. (Very rarely a patient might inhale an extremely large amount and start to have these effects plus dyspnea within 2 hours. This patient should be intubated, and assisted ventilation with oxygen should be started. This patient should be taken to the nearest appropriate hospital as quickly as possible.)

- Treatment
  - There is nothing to do for these patients until effects appear except to decontaminate. Tissue is damaged within minutes, so decontamination must be done immediately.
  - Eyes: Any commercial eye solution may relieve the irritation from a mild exposure. More severe effects: A mydriatic b.i.d. or q.i.d. (depending on the length of action of the drug): a topical antibiotic b.i.d.; Vaseline on lid edges b.i.d.; sunglasses if photophobia is present. Topical steroids within the first 24 hours only may reduce inflammation. Control pain with systemic, not topical, analgesics. Visual loss is usually due to lid edema and blepharospasm, not eye damage.
  - Skin: A soothing lotion (e.g., calamine) for erythema. Leave small blisters intact. Unroof large blisters and irrigate denuded area at least t.i.d. followed by liberal application of topical antibiotic. Watch for infection. Fluid requirements are much less than those for thermal burns; do not overhydrate.
  - Airways: Steam inhalation and cough suppressants will generally relieve mild symptoms. A chemical pneumonitis (increased temperature, white blood count; chest x-ray findings) may develop after large exposure: intubation, assisted ventilation with oxygen (and possibly with PEEP or CPAP); bronchodilators; watch sputum at least daily for organisms (no antibiotics until organism is identified)
  - Systemic absorption of a large amount of mustard may cause bone marrow and gastrointestinal tract damage. Watch WBC, Hct daily; mustard damages bone marrow.

Nerve Agents

Tabun (GA); Sarin (GB); Soman (GD). None for GF and VX

Military Designations: GA, GB, GD, GF and VX

Description: Nerve agents are very toxic organophosphorus compounds that have biological activity similar to that of many insecticides. Their volatilities range from that of water to that of motor oil; they present a hazard from vapor and liquid. Under temperate conditions, the liquids are clear, colorless, and mostly odorless. They cause biological effects by inhibiting acetylcholinesterase, thereby allowing acetylcholine to accumulate and cause hyperactivity in muscles, glands, and nerves.

Non-Military Use: There is no non-military use. Threat of human exposure exists in research laboratories, in storage facilities, and from terrorists.

Treatment Protocol

- General
  - Nerve agents are extremely toxic chemicals that cause effects by inhibiting the enzyme acetylcholinesterase, allowing excess acetylcholine to accumulate. This excess neurotransmitter then produces overstimulation and causes hyperactivity in muscles, glands and nerves the nerve agents are GA (Tabun), GB (Sarin), GD (Soman), GF, and VX. Their effects are identical.
  - Remove patient from contaminated atmosphere. If exposure was to vapor, remove clothing; if exposure was to liquid; remove clothing and wash skin with soap and water, or thoroughly flush with water alone.
- Patient evaluation
  - If patient is conscious, note ventilatory status and ask about nausea. If unconscious, note ventilatory status and heart rate (heart rate may be high, low, or normal in a nerve agent casualty).
  - Initial effects differ depending on whether exposure was to vapor or to liquid.
  - Vapor: Effects start within seconds to a minute or two.
    - Mild to moderate: Miosis, possible redness in eye, eye pain, complaints of dim or blurred vision, nausea, rhinorrhea, excess secretions, dyspnea (mild to severe).
    - Severe: Loss of consciousness, seizures, apnea, flaccid paralysis.
  - Liquid: Effects start in minutes (large exposure) to 18 hours (small exposure) after an asymptomatic interval.
    - Mild to moderate: Sweating and fasciculations at site of exposure; nausea, vomiting, diarrhea; weakness.
    - Severe: Same as for vapor, but after a 1- to 30-minute asymptomatic interval.

- Treatment
  - Initial Management
    - Mild to moderate: Dyspnea should be treated with one or two doses of atropine IM or IV and 1 dose of pralidoxime (IV drip) initially, depending on severity of the dyspnea. (See paragraph B below for size of dose.) This should be supplemented with oxygen, particularly in infants, young children, and the elderly; healthy older children and adults will usually do well without it unless they have pulmonary or cardiac disease. Atropine dose should be repeated at 5-to 10-minute intervals until improvement is noted. Failure to respond, (i.e., no dry mouth, no decrease in secretions) confirms the need to administer additional doses of atropine. Gastrointestinal effects after liquid exposure are treated in the same manner. Do not treat for miosis (unless eye pain is severe) or rhinorrhea (unless severe).
    - Severe: Administer three doses of atropine IM (not IV in hypoxic patient) and start one dose of pralidoxime by slow (20 minutes) IV drip. (More rapid administration will cause hypertension.) (See paragraph B below for size of dose.) Intubate and ventilate with oxygen (initial ventilation will be difficult because of airway resistance; atropine will relieve this). Administer diazepam if convulsing. Suction for secretions. Repeat 1 dose of atropine (IM until hypoxia is improved, then IV) every 5 minutes until (a) secretions diminish or (b) airway resistance is less or is normal. Failure to respond, (i.e., no dry mouth, no decrease in secretions) confirms the need to administer additional doses of atropine. Monitor via pulse oximeter; cardiac monitoring should also be done (cardiac arrhythmias are uncommon after atropine is given). Acidosis may develop after seizures or after period of hypoxia and will require therapy. This patient should be transported to a hospital after stabilization (adequate drug therapy and initiation of ventilation).
    - Eyes: Do not treat miosis unless eye/head pain is severe. Use topical, not systemic, anticholinergic to relieve pain.
  - Recommended Doses

    <u>Atropine:</u>
    - Older child and adult: 2 mg
    - Infant and young child: 0.02 mg/kg
    - Elderly: Use adult dose unless cardiac or pulmonary disease is present, or patient is small or frail; in latter instances, use 1 mg as standard, but be prepared to administer additional amounts more frequently.

Pralidoxime (2-PAM):

- Older child and adult: 1 gram
- Infant and young child: 25-50 mg/kg
- Elderly: Adult dose unless cardiac or renal disease is present, patient has hypertension, or patient is small and frail; decrease dose by half in these patients but administer the other half 1 hour later if patient has not improved. Pralidoxime can cause hypertension when given rapidly IV. Slow administration over 20 minutes will minimize the hypertensive effect. After rapid administration, hypertension can be rapidly but transiently reversed by phentolamine (adult: 5 mg IV. child: 1 mg, IV).

o Further Care

- Mild to moderate: After vapor exposure, a patient who is breathing normally does not need to be hospitalized as he will not worsen. However, miosis should be followed until eyes are normal (4 to 6 weeks). After liquid exposure, a patient should be observed in hospital for 18 hours until all agent is absorbed from skin.
- Severe: Continue to ventilate and to administer atropine following guidelines above. Treat acidosis if present. If patient has not had prolonged hypoxia, recovery of an unconscious patient will be gradual over l to 3 hours.