Chemical Terrorism Fact Sheet

Organophosphates/Nerve Agents

Illustration of nerve axonal terminal, synaptic activity, and glandular secretion
Photo Courtesy Department of Defense

Protective Equipment/Detection

Semi-permeable, active carbon containing, protective clothing and a full-face gas mask with appropriate filter are the only gear that can fully protect against nerve agents. If unavailable, protective gowns, masks, and gloves can minimize skin exposure.

Single and three-color detector papers are available for individual use to detect liquid nerve agent. Area detectors and monitoring devices are also available through military or emergency management contacts.

Decontamination

Tabun, Sarin, Soman, and **VX** hydrolyze rapidly in strongly alkaline or chlorinated solutions. Decontamination procedures for skin, equipment and material include active neutralizing chemicals (chloramine solutions, 5% bleach) or neutral adsorbing powders (Fullers earth). Copious amounts of water can also dilute and remove these agents. The victim's body fluids, urine and feces do not present a hazard. Safe removal and containment of the victim's clothing is essential and decontamination is critical to prevent healthcare workers from becoming casualties.

Signs and Symptoms

Nerve agents and organophosphate insecticides inhibit tissue cholinesterases at synaptic sites, and cause the accumulation of excess acetylcholine at nicotinic and muscarinic receptors. The earliest signs depend upon route of exposure: respiratory signs if inhaled, GI disturbances if ingested, and local skin signs with skin contact, although respiratory distress quickly predominates in moderate to severe exposures. In such exposures, if death is delayed, the muscarinic effects become dominant, followed by the nicotinic effects. If there is no eye contact, the ocular signs may come later in the progression of symptoms. Symptoms following inhalation are immediate, while symptoms following mild skin exposure can be delayed as much as 18 hours. The estimated LCt_{50}s by inhalation are 400 mg-min/m^3 for **Tabun**, 100 mg-min/m^3 for **Sarin**, 50 mg-min/m^3 for **Soman** and 10 mg-min/m^3 for **VX**. Percutaneous LD_{50}s are 1000 mg, 1700 mg, 350 mg, and 6-10 mg, respectively.

Following a localized skin exposure expect meiosis, usually pinpoint and sometimes unequal; frontal headache; nausea and vomiting; weakness; and fasciculations or sweating at the exposure site. With severe exposures, you will also note eye pain on focusing; dimmed vision; rhinorrhea; chest tightness; wheezing suggestive of increased secretions and bronchoconstriction; cough; generalized muscular twitching, weakness, or paralysis; convulsions; loss of consciousness; and loss of bladder and bowel control.

Chemical Overview

Organophosphates are a diverse, and widely stocked, group of chemical agents available in liquid, gas or aerosol form. The military forms, known as nerve agents/gases, are absorbed through the skin or lungs, usually within 20-30 minutes. There are two types: G-agents (non-persistent, death by inhalation), and V-agents (persistent, death by inhalation or skin, conjunctival, and mucosal absorption). Military grade nerve agents are **Tabun (GA), Sarin (GB), Soman (GD)** and **VX**. The more widely available organophosphates include common pesticides for home and farm use. Of these, **tetraethyl pyrophosphate (TEPP)** and **parathion** have caused numerous deaths.

Tabun (GA) (O-ethyl dimethylamidophosphorylcyanide), the first nerve gas, was developed in 1936 at IG Farben, Germany. It is the easiest to manufacture, as the necessary chemicals are available on the open market.

Sarin (GB) (isopropyl methylphosonofluoridate) is a colorless, odorless volatile liquid, soluble in water, first synthesized at IG Farben in 1938. It kills mainly through inhalation. **Cyclosarin(GF)** and **Thiosarin** are variants.

Soman (GD) (pinoacolyl methylphosphonofluoiridate) is the fastest-killing nerve gas, first produced in 1944 at IG Farben. It is lethal through both inhalation and skin contact.

VX (O-ethyl S-diisopropylaminomethyl methylphosphonothiolate) is an odorless, colorless, sticky liquid, soluble in water <10°C, which easily passes through the human skin. Discovered in the United Kingdom in 1952, the U.S. military began its production as a weapon in 1961. It is lethal through both inhalation and skin contact.

Signs and Symptoms (Continued)

Following a mild inhalation exposure expect meiosis, dimmed vision, headache, rhinorrhea, salivation, and dyspnea with chest tightness. In severe exposures, you will also note slight chest pain; increased bronchial secretions; pulmonary edema; cyanosis; anorexia; abdominal cramps; "heartburn" and eructation; diarrhea; tenesmus; involuntary defecation; increased sweating, salivation, and lacrimation; slight bradycardia; urinary frequency; involuntary micturition; easy fatigue; muscular twitching; fasciculations; generalized weakness, including respiratory muscles; pallor; occasional elevation of blood pressure; giddiness; anxiety or jitteriness; emotional lability; excessive dreaming; insomnia; nightmares; apathy; withdrawal and depression; drowsiness; difficulty in concentrating; slowness of recall; confusion; slurred speech; ataxia; and, ultimately, coma, with absence of reflexes; Cheyne-Stokes respiration; convulsions; depression of respiratory and circulatory centers; and hypotension.

Besides symptomatology, measurement of decreased cholinesterase activity in blood is the only presently available method for rapid diagnosis of exposure to nerve agents. However, such testing is non-specific and is only useful when >20% cholinesterase inhibition is present. At that point, severe meiosis, headache, eye pain, conjunctival hyperemia, rhinorrhea, and chest tightness are already evident.

Treatment

Full recovery may occur after a single, mild to moderate exposure. However, repeated daily exposures are cumulative and may result in severe poisoning. Moderate to severe poisonings necessitate treatment for survival, as inhibition of acetylcholinesterase rapidly becomes more or less irreversible.

First aid for nerve agent victims is basic. Remove them from additional exposure. Flush the eyes with copious amounts of water for 10-15 minutes. Decontaminate the skin with liquid household bleach and flush with water. For ingestions, administer activated charcoal and a cathartic. DO NOT induce vomiting. If needed, begin CPR, avoiding direct mouth-mouth contact.

The mainstays of treatment are anticholinergic and anticonvulsant agents. Atropine sulfate, an antimuscarinic agent, blocks the parasympathetic effects in the periphery and partially counteracts the convulsive effects and respiratory depression in the CNS. Loading doses range between 1 and 5 mg IV every 30 minutes until full atropinization (dry mouth, skin, and bronchi; and heart rate >90 per minute), and maintenance should continue for at least 24 hours at doses between 0.5 and 2 mg/hr. Be aware of potential arrhythmias secondary to the atropine. Titration of atropine in the individual patient is based on producing a decrease in bronchial constriction and secretions. Heart rate changes are easier to follow but less important. Besides atropine, a central acting anticonvulsant should be given, with diazepam (10mg IM initially) being the preferred agent. Assisted ventilation and general supportive measures will also be required, sometimes for several days

Oximes, which are acetylcholinesterase reactivators, relieve the important nicotinic symptoms of skeletal neuromuscular blockade. Most clinical experience is with pralidoxime chloride (2-PAM, Protopam chloride R), pralidoxime methanesulfonate (P2S) or methylsulfate (Contrathion R), and obidoxime chloride (Toxogonin R). These agents have poor CNS penetration and must be repeatedly injected or given as a loading dose followed by a maintenance dose.

Additional information and references available at http.www.bioterrorism.slu.edu

CSB&EI
A Division of Saint Louis University School of Public Health

Long-term Medical Sequelae

Full recovery can take up to 3 months and, following recovery, increased susceptibility may persist for up to 3 months. Persistent paralysis, organophosphate induced delayed neuropathy (OPIDN), and axonal death followed by demyelination, have been reported in animal exposures to **Sarin**, but not in humans to date.

Environmental Sequelae

Tabun lasts 1-2 days (weather dependant), takes 20 times as long as water to evaporate and persists in water one day at 20°C and six days at 5°C. **Sarin** has little persistence, evaporating as fast as water or kerosene. **Soman** lasts 1-2 days (weather dependant) and takes 4 times as long as water to evaporate. Thickeners can extend its persistence. **VX** can persist for weeks to months, particularly in temperatures near or below 0°C, and evaporates 1,500 times slower than Sarin.

Prophylaxis

For pretreatment (prophylaxis), a reversible anticholinesterase agent, pyridostigmine, is recommended at a dose of 30 mg, 3 times daily, to produce a blood cholinesterase inhibition of about 30%. In severe poisonings, this 30% level of inhibition will allow the spontaneous reactivation of these inhibited cholinesterases and the recuperation of the victim.

Disclaimer

Information contained in this fact sheet was current as of August 2002, and was designed for educational purposes only. Medication information should always be researched and verified before initiation of patient treatment.

August 2002