

## THE FACTS ABOUT NERVE AGENTS

### TECHNICAL INFORMATION

**Note to reader:** This fact sheet is intended to provide general awareness and education on specific chemical agents. For information on preparedness and response (e.g., for first responders and emergency medical personnel), please refer to the following Department resources:

Chemical Terrorism Preparedness and Response Card

([http://www.health.state.ny.us/nysdoh/bt/chemical\\_terrorism/pdf/chemical.pdf](http://www.health.state.ny.us/nysdoh/bt/chemical_terrorism/pdf/chemical.pdf))

Chemical Terrorism Wall Chart

([http://www.health.state.ny.us/nysdoh/bt/chemical\\_terrorism/pdf/poster.pdf](http://www.health.state.ny.us/nysdoh/bt/chemical_terrorism/pdf/poster.pdf))

#### What are nerve agents?

The principal nerve agents are sarin (GB), soman (GD), tabun (GA), and VX. They are manmade compounds that have been manufactured for use in chemical warfare. These agents are known to be present in military stockpiles of several nations, including the United States. Nerve agents are organophosphorus compounds that are similar in mechanism of action to some pesticides (i.e., organophosphate and carbamate insecticides).

Some of the chemical/physical properties of nerve agents include:

- Nerve agents are liquids at room temperature; VX has an oily consistency.
- Nerve agents are very soluble or miscible in water, and soluble in most organic solvents.
- Sarin evaporates from surfaces nearly as fast as water, but the other nerve agents take longer to evaporate. VX evaporates most slowly, at a rate similar to that of motor oil.
- The vapor density of nerve agents is at least several-fold greater than air, with VX having the highest vapor density of these agents (about 9-fold greater than air). Following evaporation, agents will tend to stay near the ground.
- The compounds are either odorless or have only a slight odor.

#### How can people be exposed to nerve agents?

Nerve agents do not occur naturally. The public could be exposed to nerve agents if there is a terrorist attack or an accidental release from a military storage facility.

#### What is the mechanism of action for nerve agents?

Nerve agents inhibit cholinesterase enzymes in plasma, erythrocytes and at cholinergic nerve endings in tissues. Once tissue cholinesterase is inhibited by the nerve agent, the enzyme cannot hydrolyze the neurotransmitter acetylcholine. Consequently, acetylcholine accumulates and causes prolonged stimulation of the affected tissues. The bond between the nerve agent and the enzyme is permanent unless antidotes are administered. Enzyme activity will slowly return to normal without antidotes, but only as new cholinesterase is synthesized or with erythrocyte turnover.

**What are the specific signs and symptoms of nerve agent poisoning?**

Nerve agents are highly toxic, and even small amounts can cause health effects if they are inhaled, ingested or if they contact skin or eyes (as little as 10 milligrams VX on skin can be fatal). Health effects occur more rapidly from inhalation and ingestion exposure (within seconds to minutes) than from dermal or ocular exposure. Effects from less severe dermal exposures can take a number of hours to manifest.

Regardless of the route of exposure, nerve agents can cause the following characteristic effects:

- miosis (may not occur unless exposure is from vapors, direct contact or severe in extent)
- rhinorrhea
- excessive salivation, sweating and lacrimation
- headache
- nausea and vomiting
- abdominal pain
- chest tightness and dyspnea
- involuntary urination and defecation
- muscle twitching/fasciculations
- seizures
- coma
- death

**How is nerve agent exposure treated?**

Often the most important first step in treating nerve agent exposure is to remove the patient from the point of exposure to fresh air and to begin decontamination. Decontamination is normally done by removing contaminated clothing, thoroughly washing body and hair with soap and water, and flushing eyes with large amounts of water or saline solution. Contaminated clothing should be double-bagged after removal to prevent further exposure. It is important that anyone treating a contaminated person should wear appropriate personal protective equipment to avoid exposure.

Nerve agent poisoning can be treated with the antidotes atropine and pralidoxime chloride (2-PAM chloride). Atropine has anticholinergic properties that are particularly effective at peripheral muscarinic sites, but are less effective at nicotinic sites. 2-PAM chloride cleaves the nerve agent from the cholinesterase enzyme and restores the enzyme's activity. In contrast to atropine's action, the effects of 2-PAM chloride are most noticeable at tissues with nicotinic receptors; muscarinic effects are not observably altered. The efficacy of 2-PAM chloride for treating patients decreases as time elapses due to the strengthening or "aging" of the nerve agent-enzyme bond. This so-called "aging" occurs most rapidly with soman, and 2-PAM chloride may be ineffective for exposures to soman unless administered within several minutes of exposure. Repeated administration of both atropine and 2-PAM chloride may be needed to reverse the effects of nerve agents on patients. Benzodiazepine administration may also be necessary to control seizures, and phentolamine may be needed to treat 2-PAM chloride-induced hypertension.

Both atropine and 2-PAM chloride are available to medical professionals as spring-loaded auto-injector syringes for intramuscular administration. Mark I kits consist of one syringe containing 2 are designed for adults and these kits have not been approved by the U.S. Food and Drug Administration for use in children. Atropine alone in auto-injector form is available as the AtroPen in amounts of 0.5, 1.0 and 2.0 mg. 2-PAM chloride alone is available in auto-injector form as the 600 mg ComboPen. Although the spring-loaded design of the auto-injectors can cause tissue damage in children and smaller patients, these devices can be useful when intravenous administration of antidotes would be too time consuming or not practical.

For specific information on using antidotes in the pediatric population, see the website: <http://www.ncdp.mailman.columbia.edu/AtropineAutoInjectorV1N1.pdf> under *Study Results: Atropine Brief*.

**NERVE AGENT ANTIDOTE RECOMMENDATIONS**

Patient	Mild/ Moderate Effects <sup>1</sup>	Severe Effects <sup>2</sup>	Other Treatment
<b>Child</b>	Atropine: 0.05 mg/kg IM, IV (minimum 0.1 mg, maximum 5 mg);  <b>and</b>  2-PAM chloride: 25 mg/kg IM, IV (maximum 2 g IM, 1g IV)	Atropine: 0.1 mg/kg IM, IV (minimum 0.1 mg, maximum 5 mg);  <b>and</b>  2-PAM chloride: 50 mg/kg IM, IV (maximum 2 g IM, 1g IV)	Assisted ventilation after antidotes for severe exposure.  <b>Repeat atropine</b> at 2-5 minute intervals until secretions have diminished and breathing is comfortable or airway resistance has returned to near normal.  <b>Repeat 2-PAM chloride</b> once at 30-60 minutes, then at one-hour intervals for 1-2 doses, as necessary.
<b>Adult</b>	Atropine: 2 to 4 mg IM, IV;  <b>and</b>  2-PAM chloride <sup>3</sup> : 600 mg IM, <b>or</b> 25 mg/kg IV slowly	Atropine: 6 mg IM;  <b>and</b>  2-PAM chloride <sup>3</sup> : 1,800 mg IM, <b>or</b> 50 mg/kg IV slowly	<b>Diazepam</b> for seizures: Child — 0.05 to 0.3 mg/kg IV (maximum 10 mg); Adult — 5 mg IV  <b>Other benzodiazepines (e.g. lorazepam, midazolam)</b> may provide relief.  <b>Phentolamine</b> for 2-PAM chloride-induced hypertension: 1 mg IV for children; 5 mg IV for adults.

1. **Mild/Moderate effects of nerve agents** include localized sweating, muscle fasciculations, nausea, vomiting, weakness, dyspnea.
2. **Severe effects of nerve agents** include unconsciousness, seizures, apnea, flaccid paralysis.
3. Dose selection of 2-PAM chloride for elderly patients should be cautious (usually starting at 600 mg IM, or 25 mg/kg IV slowly) to account for the generally decreased organ functions in this population.

**Will laboratory tests assist in making treatment decisions if someone has been exposed to nerve agents?**

Medical tests are available, but any delay in administering antidotes to draw blood or collect urine could endanger patient welfare, and results are of limited clinical value. One test measures the acetylcholinesterase activity level of erythrocytes as a determinant of biological effect. However, knowledge of activity levels is not likely to alter the course of treatment, and without knowledge of an individual’s pre-exposure acetylcholinesterase activity level (as baselines vary among individuals due to a number of factors), interpretation of results may be difficult. Other tests can measure metabolites of nerve agents in urine, but their measurement is of little value in treating acute poisoning cases.

**How can I get more information about nerve agents?**

Call the following numbers, or visit the websites listed among the "Sources".

- Centers for Disease Control and Prevention Public Response Hotline: (1-888-246-2675)
- Agency for Toxic Substances and Disease Registry (1-888-422-8737)
- Regional Poison Control Center (1-800-222-1222)

**Sources:**

Agency for Toxic Substances and Disease Registry. 2002. ToxFAQs for Nerve Agents. Division of Toxicology, U.S. Department of Health and Human Services. Public Health Service; Atlanta, GA.

**<http://www.atsdr.cdc.gov/toxfaq.html>**

Agency for Toxic Substances and Disease Registry. 2003. Medical Management Guidelines for Nerve Agents. Division of Toxicology, U.S. Department of Health and Human Services. Public Health Service; Atlanta, GA.

**<http://www.atsdr.cdc.gov/MHMI/mmg166.html>**

Centers for Disease Control and Prevention. 2003. Public Health Emergency Preparedness and Response Sheets. U.S. Department of Health and Human Services. Public Health Service; Atlanta, GA.

**<http://www.bt.cdc.gov/Agent/Agentlistchem.asp>**

U.S. Army Medical Research Institute of Chemical Defense (USAMRICD). 2000. Medical Management of Chemical Casualties Handbook, Third Edition. Chemical Casualty Care Division. Aberdeen Proving Grounds: Aberdeen, MD.

**<https://ccc.apgea.army.mil/sarea/products/handbooks/MMCC/mmccthirdeditionjul2000.pdf>**

This fact sheet is based on the most current information. It may be updated as new information becomes available.

Fact sheet updated: July 23, 2004