



NERVE AGENT INFORMATION FOR EMERGENCY MEDICAL SERVICES AND HOSPITALS

Meticulous attention to standard protocols for personal protection, recognizing toxidromes, and treating patients continues to be the best way to prepare for and respond to chemical agent exposures

PURPOSE

This document provides a quick refresher on standard protocols for recognizing, treating, and protecting yourself from nerve agent exposures. Comprehensive follow-up guidance for Law Enforcement, Fire, EMS, HazMat, and Hospital-Based First Receivers incorporating lessons learned and best practices from the recent United Kingdom incidents will be forthcoming.

BACKGROUND

Nerve agents are extremely toxic chemical warfare agents. Several nerve agents exist and are generally categorized as either “high volatility” or “low volatility” chemicals, a measure of how likely they are to disperse in air. A high volatility nerve agent (easily dispersed in air) means that the exposure is likely to occur from breathing in its vapors resulting in the rapid onset of symptoms. A low volatility nerve agent (not easily dispersed in air) typically gets absorbed through the skin and has a delayed onset of signs and symptoms. An example of a high volatility nerve agent is sarin, whereas VX is a low volatility agent. In the body, a nerve agent exerts its effects by inhibiting an enzyme (acetylcholinesterase), resulting in acute illness – specifically, cholinergic crisis. Organophosphorus or carbamate pesticides produce similar effects to nerve agents.

SIGNS AND SYMPTOMS OF NERVE AGENT POISONING

Caveat: Poisoned patients may not demonstrate all of these symptoms

- **Mouth/Skin:** Drooling (Salivation), foaming at the mouth, and excessive sweating
- **Nose/Eyes:** Runny nose and watery eyes (Lacrimation) with small (often pinpoint) pupils (Miosis)
- **Chest:** Cough, chest tightness, difficulty in breathing, wheezing, respiratory failure, “wet” fluid filled lungs
- **Abdominal:** Urination, Diarrhea, abdominal (Gastrointestinal) cramps, belching, nausea, and/or vomiting (Emesis)
- **Mental Status:** Confusion, drowsiness, slurred speech, ataxia, unconsciousness, coma
- **Muscle/Neurological:** Fatigue, weakness, twitching, tremors, cramps, absent reflexes, seizures

Underlined findings = “**SLUDGE**” - **S**alivation, **L**acrimation, **U**rination, **D**iarrhea, **G**astrointestinal cramps, **E**mesis

Other mnemonic used = “**DUMBBELS**” – **D**iarrhea, **U**rination, **M**iosis/**M**uscle weakness, **B**ronchospasm/**B**ronchorrhea, **B**radycardia, **E**mesis, **L**acrimation, **S**alivation/**S**weating

| Clinical Effects of Nerve Agents versus Opioids | | |
|---|--|-----------------------------------|
| | Nerve Agent | Opioid |
| Nose | Runny nose | Normal |
| Airway | Secretions/drooling/foaming at the mouth | Normal |
| Breathing / Respiratory status | Increased work of breathing/chest tightness/wheezing/difficulty in breathing/cough/“wet” fluid filled lungs– more prominent with inhaled exposure; dermal exposure may not cause bronchoconstriction or bronchorrhea | Decreased respiratory rate |
| Heart rate | Slowed | Normal |
| Mental Status / Neurological | Slow/unconscious/seizures/confusion/slurred speech/ataxia/coma/absent reflexes/ tremors | Slow or unconscious/coma/seizures |
| Eyes | Tearing/small pupils-pinpoint | Small pupils-pinpoint |
| Skin | Wet/sweaty/cyanosis | Normal/cyanosis |
| Gastrointestinal | Belching/cramps/vomiting/diarrhea | Normal |
| GU | Urination | Normal |
| Muscles | Fatigue/weakness/twitching/ cramps | Normal |

A KEY DISTINCTION BETWEEN NERVE AGENT POISONING AND OPIOID POISONING IS “SLUDGE” OR “DUMBBELS.”

DETECTION (IF YOU STRONGLY SUSPECT A NERVE AGENT)

- Contact HazMat or special operations teams
- Notify the local FBI Field Office WMD coordinator

PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Emergency responders should have the proper training and education to work with hazardous materials.
- Those providing or assisting with patient care including decontamination should follow institutional policy for a chemical incident, wearing a recommended chemical protective suit, gloves, boots, and respiratory protection to prevent any secondary exposure from patients or objects.
- After patient decontamination is complete, providers should wear a gown and a double layer of nitrile gloves during patient contact.

PATIENT DECONTAMINATION

- A person potentially exposed to a nerve agent should be decontaminated whether they develop signs of acute illness or not.
- Removal of clothing is a vital step to reduce ongoing and secondary exposure. Responders should pay particular attention to the risk of secondary exposure during clothing removal. Double bagging removed clothing is ideal.
- Wiping skin with a paper towel, dry wipe, or other cloth will also contribute to effective decontamination. This dry decontamination step can be performed by patients themselves and, along with clothing removal, should be done as early as possible.
- If contamination with liquid agent is suspected, patients should be decontaminated with water, ideally with a high-volume, low-pressure shower, including soap if available, gentle rubbing with a soft cloth or sponge, and active drying with a clean towel after the shower.
- If Reactive Skin Decontamination Lotion (RSDL) is available, it is recommended for spot decontamination.

TREATMENT*

- Nerve agent toxicity is the result of excessive acetylcholine, causing cholinergic crisis. Therapy focuses on treating the excessive secretions and bronchospasm with anticholinergic medications such as atropine with dosing titrated to respiratory secretions and airway resistance. Pralidoxime chloride (2-PAM Cl), a specific nerve agent antidote, augments the primary therapy of atropine; continuous infusions may be beneficial.
- Seizures should be managed with escalating doses of benzodiazepines (midazolam, lorazepam, or diazepam). All patients, even without convulsions, who meet the severe criteria should be treated with midazolam, lorazepam, or diazepam 10 mg IV/IM/IO. A pediatric patient in this setting is defined as an individual less than 18 years old AND with an ideal body weight (IBW) of ≤ 40 kg. If IBW is > 40 kg, adult medication and dosing are more appropriate. For patients under 40 kg, use midazolam only: 0-13 kg – 70 mcg/kg, >13-40 kg – 5 mg.
- Autoinjectors (AI) are a convenient means of rapidly administering drugs to treat nerve agent exposure, which may be especially useful pre-hospital or at a hospital managing a large number of patients. However, only certain drugs in specific doses are available in autoinjectors: DuoDote or Antidote Treatment Nerve Agent Autoinjector (ATNAA) or Mark 1 kit (atropine 2 mg/2-PAM Cl 600 mg); atropine 2 mg, 1 mg, or 0.5 mg; 2-PAM Cl 600 mg; diazepam 10 mg.

EMS AGENCIES SHOULD FOLLOW THEIR ESTABLISHED TREATMENT PROTOCOLS

*National Model EMS Clinical Guidelines are also acceptable: <https://www.nasemso.org/Projects/ModelEMSClinicalGuidelines/>

NOTE: dosages in the model clinical guidelines are based on National Library of Medicine references; dosages noted below are based on the Agency for Toxic Substances and Disease Registry's medical management guidelines.

| Patient Age | Antidotes ¹ | | Other Treatment |
|----------------------|--|--|--|
| | Mild / Moderate Symptoms ² | Severe Symptoms ³ | |
| Infant (0-2 yrs) | Atropine: 0.05 mg/kg IV/IM/IO 2-PAM Cl: 15 mg/kg IV/IM/IO | Atropine: 0.1 mg/kg IV/IM/IO 2-PAM Cl: 25 mg/kg IV/IM/IO | Assisted ventilation should be started after administration of antidotes for severe exposures. Repeat atropine (2 mg IV/IM) at 5- 10 minute intervals until secretions have diminished and breathing is comfortable or airway resistance has returned to near normal. |
| Child (2-10 yrs) | Atropine: 1 mg IV/IM/IO 2-PAM Cl: 15 mg/kg IV/IM/IO | Atropine: 2 mg IV/IM/IO 2-PAM Cl: 25 mg/kg IV/IM/IO | |
| Adolescent (>10 yrs) | Atropine: 2 mg IV/IM/IO/Al; 2-PAM Cl: 15 mg/kg IV/IM/IO | Atropine: 4 mg IV/IM/IO/Al; 2-PAM Cl: 25 mg/kg IV/IM/IO | |
| Adult | Atropine: 2 to 4 mg IV/IM/IO/Al; 2-PAM Cl: 600 mg IV/IM/IO/Al | Atropine: 6 mg IV/IM/IO/Al; 2-PAM Cl: 1800 mg IV/IM/IO/Al | |
| Elderly, Frail | Atropine: 1 mg IV/IM/IO 2-PAM Cl: 10 mg/kg IV/IM/IO | Atropine: 2 to 4 mg IV/IM/IO 2-PAM Cl: 25 mg/kg IV/IM/IO | |

1 If 2-PAM Cl solution is needed, prepare from a vial containing 1 g desiccated 2-PAM Cl: reconstitute with 20 ml sterile water.

2 Mild/Moderate symptoms include localized sweating, muscle fasciculations, nausea, vomiting, weakness, dyspnea.

3 Severe symptoms include unconsciousness, convulsions, apnea, flaccid paralysis.

SPECIFIC PEDIATRIC CONSIDERATIONS

For pediatric patients, existing autoinjectors may provide more than the recommended doses of atropine and pralidoxime. The reference below provides a strategy to mitigate this issue if time and resources allow. This method allows you to discharge the contents of autoinjectors and dilute the drug to prepare the proper dose. Expert opinion would still recommend that, given the benefit compared to the possible harm in delaying treatment, severe patients should be treated with autoinjectors even if they provide doses above recommendations.

Corvino TF, Nahata MC, Angelos MG, Tschampel MM, Morosco RS, Zerkle J, Nelson RN. Availability, stability, and sterility of pralidoxime for mass casualty use. Ann Emerg Med. 2006 Mar; 47(3):272-7.

ADDITIONAL CONSIDERATIONS

- If faced with a mass casualty incident and if pharmaceutical therapies become exhausted, consider contingency medical countermeasures at your discretion.
- Poison Control Centers provide 24-hour-a-day patient care support at 1-800-222-1222.
- The Secretary of Health and Human Services issued a declaration, effective April 11, 2017, under the Public Readiness and Emergency Preparedness Act (PREP Act) to provide liability immunity to certain individuals and entities against any claim of loss relating to the use of medical countermeasures against nerve agents, given certain conditions are met:
<https://www.federalregister.gov/documents/2017/05/10/2017-09455/nerve-agents-and-certain-insecticides-organophosphorous-and-or-carbamate-countermeasures>

OTHER RESOURCES

U.S. Department of Health and Human Services

Centers for Disease Control and Prevention /
Agency for Toxic Substances and Disease Registry

<https://emergency.cdc.gov/agent/nerve/index.asp>

<https://www.atsdr.cdc.gov/mmg/mmg.asp?id=523&tid=93>

Office of the Assistant Secretary for Preparedness and
Response

https://chemm.nlm.nih.gov/na_hospital_mmg.htm

Personal Protective Equipment

U.S. Department of Labor

Occupational Safety and Health Administration

<https://www.osha.gov/Publications/OSHA3370-protecting-EMS-respondersSM.pdf>

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9765

Patient Decontamination

U.S. Departments of Health and Human Services and
Homeland Security

<https://www.phe.gov/Preparedness/responders/Pages/patientdecon.aspx>

General

U.S. Department of Health and Human Services

Office of the Assistant Secretary for Preparedness and
Response

<https://asprtracie.hhs.gov/>

National Fire Protection Association

<https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=473>