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Nerve Agent Incidents and Public Health Preparedness

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Recent use of nerve agents (NAs) by terrorists and assassins exposes the need for public health responders and medical preparedness personnel to work together (1). Health care providers might find themselves at the scene of such an attack. Would the involvement of an NA be recognized? What should be done immediately to assess the situation, treat the victims, protect others and oneself, and alert appropriate health officials? These are essential questions a health care provider in the vicinity of an attack might face. We provide an overview of key clinical and public health concerns related to this topic for health care practitioners and public health officials.

Recognizing NA Exposure

Nerve agents are among the most lethal agents of chemical warfare. Their development, production, acquisition, stockpiling, and retention are prohibited by the 1997 Chemical Weapons Convention, which was signed by 192 nations, including the United States (2). Nerve agents are organophosphorus compounds and are in a similar chemical class to some insecticides. They inhibit the enzyme acetylcholinesterase, which normally inactivates the neurotransmitter acetylcholine at neuronal junctions. Exposure to NAs results in enhanced and prolonged stimulation of muscarinic and nicotinic cholinergic receptors in the peripheral and central nervous systems (3). Health care providers may be challenged to differentiate NA-associated illness from opioid poisoning because of similar clinical effects (Table). A key distinction is the cholinergic signs and symptoms that are seen after exposure to NAs and generally absent in opioid poisoning. A mnemonic for some of these signs and

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symptoms is “SLUDGE:” salivation, lacrimation, urination, diarrhea, gastrointestinal cramps, and emesis. Prominent bradycardia, broncho-spasm, bronchorrhea, weakness, and fasciculations may be evident and depend on such variables as dose, exposure route, and clinical course (5). Treatment of NA poisoning includes the following medical countermeasures: atropine (blocks acetylcholine receptors from excessive stimulation), pralidoxime (prevents acetylcholinesterase deactivation by NA), and benzodiazepine (controls seizures or severe fasciculations) (6).

Sarin, cyclosarin, soman, tabun, and VX are the most well-known NAs. They are classified on the basis of their volatility, defined as the tendency to evaporate at room temperature. Sarin, cyclosarin, soman, and tabun are high-volatility NAs, whereas VX is a low-volatility NA. Breathing in vapors of a high-volatility NA may result in rapid onset of symptoms. Low-volatility NA poisoning is more likely to occur from dermal absorption, which can result in delayed onset of signs and symptoms. Low-volatility NAs are more persistent in the environment and may pose a greater risk for secondary contamination, which would place health care providers who respond to these incidents without appropriate personal protective equipment at significant risk. If NA release is suspected, first responders should use such equipment and exposed patients should be decontaminated.

Rapid Notification of Public Health Officials

Health care providers should notify public health officials early to mobilize emergency medical and public health resources. A comprehensive online resource is Chemical Hazards Emergency Medical Management (CHEMM, https://chemm.nlm.nih.gov). It provides information that may aid recognition of an NA exposure and how to alert appropriate authorities, protect oneself and others, and decide what onsite actions are and are not safe. Other resources available by telephone to responders and clinicians include their local hazardous material (HazMat) response team, their regional poison control center (1-800-222-1222), and emergency services (911).

The Laboratory Response Network and Strategic National Stockpile

Rapid laboratory analysis capacity is needed during response to incidents involving NAs. In 1999, the Laboratory Response Network was established in the United States as a collaboration among the Association of Public Health Laboratories, the Federal Bureau of Investigation, and the Centers for Disease Control and Prevention to improve the capabilities, turnaround time, and capacity of U.S. public health laboratories. The part of the network responsible for chemical threats (LRN-C) consists of 54 laboratories that are run by states, territories, and large cities and receive technical and funding support from the Centers for Disease Control and Prevention. The capabilities of the LRN-C include emergent testing of clinical samples for specific chemical agents of concern. It aims to promptly report accurate laboratory results on a limited number of clinical samples to support the response to a public health incident. In light of the surge and escalation of laboratory capacity during such incidents, another goal is to support response activities by analyzing, interpreting, and reporting results from the initial few clinical samples and from thousands of later samples

(7). The LRN-C is engaged by contacting the public health laboratory of each state health department.

During an NA mass casualty incident, prompt access to sufficient quantities of medical countermeasures (for example, antidotes) will be a public health challenge. Community hospitals may not stock the amount of medical countermeasures needed because of the relative rarity of these incidents. To address this gap, the Centers for Disease Control and Prevention's Strategic National Stockpile established the CHEMPACK program in 2002. The program places containers of atropine, pralidoxime chloride, and diazepam (autoinjectors and vials) at locations of the state's choosing, mostly within hospitals, fire departments, and emergency medical services for urgent mobilization. These medical countermeasures are federally owned but locally managed, are integrated into community response plans, and can be immediately used in an emergency without federal permission. Access to CHEMPACK contents is through local response mechanisms that vary by jurisdiction. Some may include requests through or consultation with poison centers, and others may involve activation of HazMat teams, fire departments, or other community or hospital response plans (8). Health care providers may benefit from becoming familiar with their local response plan.

Remaining Challenges

Although these advancements have improved community preparedness for chemical incidents, many challenges remain. Because health care facilities play a prominent role in community preparedness, persistent challenges include inaccurate risk perception ("It will not happen here"), high financial cost versus benefit (no perceived economic return on investment for preparedness activities), and unrealistic planning assumptions ("prompt and comprehensive community assistance is immediately available"). Solutions to these challenges may include increased research on factors that promote successful, long-term strategies for hospital preparedness; economic and noneconomic incentives for effective preparedness actions; and a more targeted approach to developing federal guidance, preparedness metrics, and supportive federal funding opportunities (9). Clinicians, poison center employees, hospital preparedness personnel, emergency managers, and public health department members will need to increase coordination, collaboration, and communication to share resources, lessons learned, and best practices.

Recent international events remind us that NAs can be used to attack individuals and pose a public health threat (10). Health care providers may benefit from learning about the local mechanisms for public health response and the resources already in place; more important, from putting them into practice in coordinated simulations, drills, and exercises.

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Table.

Clinical Effects of Nerve Agents Versus Opioid Poisoning

Variable	Nerve Agents*	Opioids†
Airway	Secretions, drooling, and foaming at the mouth	Normal
Eyes	Small or pinpoint pupils and tearing	Small or pinpoint pupils
Nose	Runny nose	Normal
Breathing/respiratory	Chest tightness; wheezing; difficulty breathing; cough; and “wet,” fluid-filled lungs	Increased time between end of expiration and inspiration
Heart rate	Tachycardia transitioning to bradycardia	Tachycardia transitioning to bradycardia
Gastrointestinal	Belching, cramps, vomiting, and diarrhea	Normal
Genitourinary	Urination	Normal
Musculoskeletal	Twitching, fasciculations, cramps, fatigue, and weakness	Normal
Mental status	Slowness, confusion, unconsciousness, and coma	Slowness, confusion, unconsciousness, and coma
Neurologic	Slurred speech, tremors, ataxia, absent reflexes, and seizures	Slurred speech, ataxia, absent reflexes, and seizures
Skin	Wetness, sweating, and cyanosis	Normal
Antidotes	Atropine, pralidoxime, and benzodiazepines	Naloxone

*See reference 2.

†See reference 4.