



## **Toxic Terrors: Nerve Agent Poisoning**

On March 20, 1995, St. Luke's Hospital treated 640 patients in the largest documented exposure of a civilian population to a warfare nerve agent. The lecturer will discuss the most common agents to expect in a mass chemical exposure from a terrorist attack. In addition, the participant will learn early recognition and treatment of such exposures.

- Describe the most common signs and symptoms of patient exposure to warfare nerve agents.
- Review other chemical agents that might be used by terrorist groups.
- Learn the most useful antidotal and supportive therapies required in such exposures.
- Recognize the need for emergency department disaster planning to handle mass casualties from hazardous substance exposures.

TH-217  
Thursday, October 14, 1999  
10:00 AM - 10:55 AM  
Room # N236  
Las Vegas Convention Center

## **FACULTY**

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# **Toxic Terror**

## **Nerve Agent Poisoning**

**The 1999 ACEP Scientific Assembly, Las Vegas**

**Mark A Kirk, MD**  
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Methodist Hospital, Clarian Partners  
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Indianapolis, Indiana

### **Course Description**

On March 20, 1995, St. Luke's Hospital treated 640 patients in the largest documented exposure of a civilian population to a warfare nerve agent. The lecturer will discuss the most common agents to expect in a mass chemical exposure from a terrorist attack. In addition, the participant will learn early recognition and treatment of such exposures.

### **Objectives**

- Learn to recognize high risk situations and clinical syndromes likely to be from terrorist attacks
- Learn how to protect yourself from exposure
- Review the resources available to assist in response to a terrorist attack
- Describe the most common signs and symptoms of patient exposure to warfare nerve agents
- Review other chemical agents that might be used by terrorist groups.
- Learn the most useful antidotal and supportive therapies required in such exposures.
- Recognize the need for emergency department disaster planning to handle mass casualties from hazardous substance exposures.
- Review the lessons learned from the events of Tokyo's sarin subway attack.

# Toxic Terrorism: Nerve Agent Poisoning

## Summary Fact Sheet

Mark A Kirk, MD  
Indiana Poison Center  
October 14, 1999

## Recognition

**Reports from the scene** of an *explosion* with dispersion of mists, liquids or gas or *paraphernalia* such as spray devices, leaking packages

Mass casualties at *potential targets* (government buildings, mass gatherings, mass transportation)

Mass casualties *without* obvious *trauma*

Mass casualties with *toxic syndromes*

*The key to identifying nerve agent poisoning is recognizing its distinct Clinical Presentation*

Pinpoint pupils, SLUDGE, Seizures, Cardiac arrest

### The Diagnostic Challenge:

Large number of victims with varying *symptoms and signs*

Eye pain, blurred vision, Pinpoint pupils, lacrimation

Cough, chest tightness, dyspnea, wheezing, apnea, cyanosis

Diaphoretic skin

Drooling, nausea, vomiting, abdominal cramps, diarrhea

Urinary incontinence

Muscle weakness, muscle cramps, fasciculations, tremor

Anxiety, confusion, seizures, coma

## Self-Protection

**Do not Touch the Stuff or Breathe the Bad Air** (Secondary contamination from skin contact with droplets or inhalation of vapor)

**Early recognition** will protect you by cautious handling and proper decontamination of victims

## First Actions

**Guard** the door (control entry into hospital)

**Decon** Procedure: **Clothing and jewelry removal**, Soap and Water shower, household bleach diluted 1:10 (sodium hypochlorite with 9 parts water)

**Triage** seriously ill based on Respiratory, Cardiovascular and CNS symptoms (START)

**Triage** walking wounded based on presence of pinpoint pupils (with vapor exposure)

**Activate** and follow mass casualty plan

**Control** hysteria

**Recognize** when you are in over your head

## Resources

### Information:

Emergency Management \_\_\_\_\_

Regional Poison Center \_\_\_\_\_

**Supplies:** Who is your Radar O'Reilly?

Antidotes needed: Atropine, Pralidoxime, Valium

Where is the atropine stored? Veterinarians, ophthalmologic, glycopyrolate for peripheral effects

## Major Pitfalls

Delay in recognizing the cause

Mass Hysteria and Medical Mass Hysteria

Secondary contamination of you, your staff, or hospital

## The Challenge: The most important requirement of management of chemical agent casualties is KNOWLEDGE

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“The health care provider’s job begins once the attack takes place, and that job is caring for casualties. Each person reading this should ask what would happen if such an attack occurred in the area of his or her hospital. Could we properly take care of the casualties? If the answer is no, perhaps the reader should ponder why.”

**“The most important, and often neglected, requirement of management of chemical-agent casualties is knowledge on the part of the health care provider. How many health care providers, from the first responder on the ambulance to the emergency physician in the hospital, feel intellectually equipped to manage a sarin casualty or a casualty from another military agent? How many feel qualified to triage more than 5,000 people to find the 1,200 or so needing medical care, as the Japanese did? There has been little training for this type of casualty in the past ....”**

“We in the United States must stop being so complacent. This type of incident can happen here. We do not like to think about it, and too often this means we do not want to hear about it and do not want to know about it. **But we must think about it, we must hear about it, and we must know about it.**”

“The Japanese medical community is to be commended for their response to the Tokyo incident. **How well will we do when faced with this new form of terrorism?”**

Sidell FR: Chemical agent terrorism. *Ann Emerg Med* August 1996;28:223-224.

### Chemical Warfare Agents

•Nerve Agents	Sarin, Soman, VX
•Cyanide	Hydrogen Cyanide
•Pulmonary Intoxicants	Phosgene, Chlorine
•Vesicants	Mustard, Lewisite
•Riot Control Agents	Pepper Spray, Mace
•Incapacitating Agents	Hallucinogens

### Recognition of Potential Terrorist Acts

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#### Recognizing High Risk Situations

Reports from the scene of an *explosion* with dispersion of mists, liquids or gas or *paraphernalia* such as spray devices, leaking packages

Mass casualties at *potential targets* (government buildings, mass gatherings, mass transportation)

Mass casualties *without* obvious *trauma*

Mass casualties with *toxic syndromes*

## **Recognizing HazMat Toxic Syndromes**

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- Irritant gas syndrome
- Chemical burns
- Metabolic poisoning
- Acetylcholinesterase poisoning
- Psychogenic illness

### **Irritant Gas Syndrome**

- Signs and Symptoms
  - Mucous membrane irritation, painful, burning skin
  - Cough, dyspnea, wheezing, pulmonary edema
- Examples: Chlorine, phosgene, ammonia, isocyanates, Hydrofluoric acid, hydrogen chloride, Riot control agents, pepper spray

### **Chemical Burns**

- Signs and Symptoms
  - Painful, burning skin, bulla, blisters, or reddened skin
  - Mucous membrane irritation
  - Systemic effects
- Examples: Acid and alkaline corrosives, Hydrocarbons, Mustard agents, Lewisite

### **Metabolic Poison**

- Signs and Symptoms
  - Nausea, vomiting, dysrhythmias, hypotension
  - Headache, syncope, seizures, coma, metabolic acidosis
  - Knocked down - cardiac arrest
- Examples: Cyanide, Hydrogen sulfide, azides, phosphine, Nerve agents

### **Acetylcholinesterase Poisoning**

- Signs and Symptoms: SLUDGE syndrome
  - Pinpoint pupils, eye pain
  - Dyspnea, wheezing, pulmonary edema
  - Headache, weakness, seizures, coma
- Examples: Nerve agents: sarin, soman, tabun, VX; Organophosphate insecticides

### **Psychogenic Illness**

- Signs and Symptoms
  - Nausea, vomiting
  - Headache, dizziness, faintness
  - Weakness, extremity numbness
  - Chest tightness, hyperventilation
- Examples: Often indistinguishable from many serious toxic exposures

# Nerve Agent Poisoning

## Chemical Properties

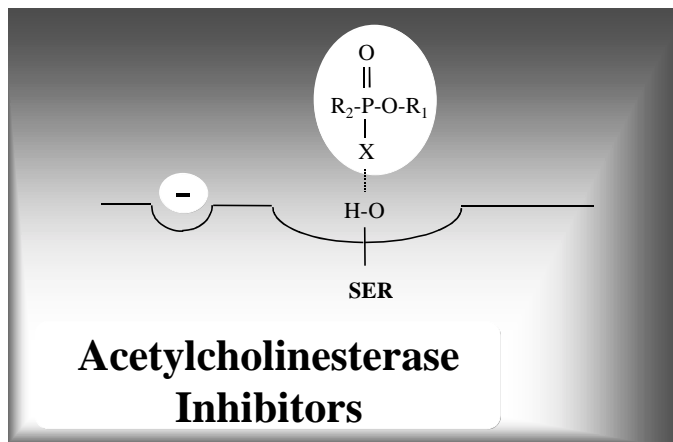
- NOT "nerve gases"
- Sarin is most volatile (volatility similar to water)
- Potency greater than organophosphate insecticides
- Heavier than air (tends to sink into low lying areas such as valleys, trenches and basements)

## Mechanism of Toxicity

Acetylcholine is a neurotransmitter that activates muscarinic and nicotinic receptors found at:

- Central Nervous System
- Parasympathetic and Sympathetic autonomic ganglia
- Postganglionic Parasympathetic Nervous System
- Sympathetic Sweat Glands
- Skeletal Muscle End Plate

Acetylcholinesterase regulates acetylcholine activity in the synaptic cleft



*Nerve agents, like organophosphate insecticides, inhibit acetylcholinesterase preventing the inactivation of acetylcholine*

Results in excess acetylcholine stimulation at muscarinic and nicotinic receptors

- **Cholinergic Storm**
- **SLUDGE Syndrome**

## Clinical Effects

- **Muscarinic**
  - Salivation
  - Lacrimation
  - Urination
  - Defecation
  - Gastroenteric cramping
  - Emesis
  - Bronchospasm/Bronchorrhea
  - Bradycardia
  - Miosis
- **Nicotinic**
  - Muscle fasciculations, twitching, cramping
  - Muscle paralysis
  - Tachydysrhythmias, hypertension
- **Central Nervous System**
  - Anxiety, restlessness, ataxia
  - Seizures
  - coma

## Clinical Effects by System

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### Respiratory

- *Respiratory failure is the major cause of death*
- Causes of Respiratory Failure:
  - 1) Increased Airway Resistance
  - 2) Bronchorrhea
  - 3) Neuromuscular Paralysis
  - 4) Depression of Central Respiratory Centers

### Central Nervous System

- Central mediated respiratory failure leading to apnea
- Rapid progression to coma
- Grand mal seizures

#### **Seizure Mechanisms**

- Cholinergic Overstimulation *Triggers* Seizures (Predominately Muscarinic)
  - Anticholinergics terminate seizures
  - No Neuropathology
- Excitatory AA Neurotransmitters *Reinforce* Seizure Activity
  - Anticholinergics less effective
- Non-Cholinergic Phase (Prolonged Seizures)
  - Refractory to Anticholinergics
  - Benzos and NMDA antagonists effective\*\*\*
  - Neuropathology Evident
  - Excessive Calcium Influx
  - Prolonged NMDA stimulation

### Ophthalmologic

- Lacrimation
- Miosis
- Unable to Dark Adapt
- Dim Vision
- Ciliary Spasm, Ocular Pain

### Musculoskeletal System

- Muscular weakness
  - Fasciculations
  - Paralysis
- \*\* *similar to succinylcholine*

### Skin

- Profuse Sweating
- Erythema

### Gastrointestinal System

- Exocrine Gland Secretions
- Increased Motility
- Relaxation of Sphincters

### Genitourinary System

- Detrusor Muscle Contraction
- Relaxation of Sphincters

### Cardiovascular System

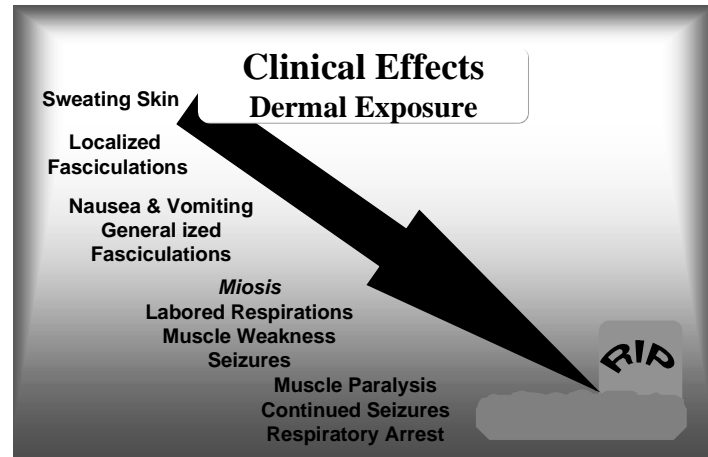
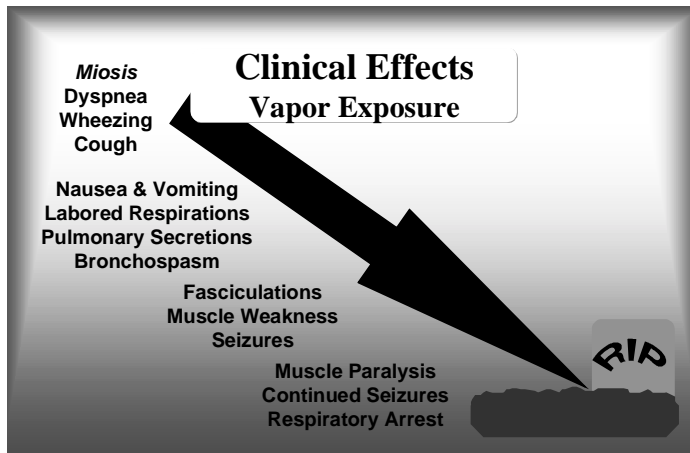
- Sinus Tachydysrhythmias
- Bradydysrhythmias
- QT prolongation and subsequent torsades

## **Tokyo Subway Sarin Attack Toxic Effects**

<b>Miosis</b>	<b>99%</b>
<b>Headache</b>	<b>75%</b>
<b>Dyspnea/Cough</b>	<b>63%</b>
<b>Nausea/Vomiting</b>	<b>60</b>
<b>Eye Pain/Blurred Vision</b>	<b>45</b>
<b>Weakness/Fasciculations</b>	<b>37</b>
<b>Running Nose</b>	<b>25</b>



## Clinical Course of Vapor and Dermal Exposure Route of Exposure Determines Signs and Symptoms



### Is it Hysteria or Poisoning?

Nerve Agent Poisoning	Hysteria
Chest Tightness Dyspnea Tachycardia Nausea/Vomiting Abdominal Cramps Involuntary Urination Fasciculations Headache Coma Diaphoresis	Chest Tightness Dyspnea Tachycardia Nausea/Vomiting Abdominal Cramps Involuntary Urination Tremor Headache Syncope Diaphoresis

### Laboratory Principles

- Useful to Confirm Exposure
  - Poor Correlation with Local Effects of Vapor Exposure
  - Systemic Effects with RBC-ChE inhibited to 20% of normal
- Preferential Inhibition: RBC over Plasma
  - VX: 70%:20%
  - Sarin: 80%:30%
  - Activity Reduced to 0 after Large Exposure

# Treating Nerve Agent Poisoning

- **Use the Simple Triage and Rapid Treatment System to Sort Patients**

What is the Respiratory Status? 0/>30/normal

What is the Perfusion Status? No radial pulse/cap refill >2 sec/ cap refill < 2 sec

What is the Neurologic Status? normal/altered/coma

**Was the Exposure Vapor or Liquid Exposure?**

**Are the pupils pinpoint (vapor exposure)**

- **Terminating Exposure**

Decontamination/ Self Protection

Rapidly Remove from Exposure

Remove Clothing

Soap and Water Shower with Specific Attention to Cleansing Hair

If available – household bleach diluted 1:10

- **Supportive Care**

Ventilation

***Patients Die a Respiratory Death***

*Why do the Seizures Stop so Quickly?*

- **Antidotes**

— Atropine

*Dose determined by improved oxygenation and ease of ventilation*

— Oximes

— Benzodiazapines

## **Alternative Sources of Atropine**

Powdered Multidose Atropine

EMS Stockpiles

Veterinary Atropine

Ophthalmic Atropine

Last Resort: Jimson Weed Tea

## **Indications for Ocular Atropine**

Distressing Ocular Pain

Need for Full Dark Adaptation

Treatment Causes Cycloplegia

Options: Ophthalmic Atropine or Cyclopentolate

## **Disposition**

- Observation for ?

Vapor = 1 hour

Liquid = Up to 18 hours

- Consider Treatment if progressive symptoms - Especially Dyspnea

- Pinpoint Pupils may persist for >45 days

## **Pitfalls of Nerve Agent Poisoning Management**

- Not Recognizing Cholinergic Excess Syndrome
- Not Understanding the Concept of Self-Protection
- Not Recognizing Delayed Effects of Dermal Exposure
- Becoming a Psychological Casualty

# Caring for Mass Casualties

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## Dealing with Mass Casualties

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- Information Management
- Resource Management
  - People
  - Antidotes
  - Decontamination Supplies
- Patient Management

### The Event: Tokyo Subway Sarin Attack

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- March 20, 1995
- 7:55 am Subway Capacity 200%
- Diluted Sarin Solution in Plastic Bags Punctured by Umbrella Tip
- 5,500 Affected
  - 4300 with No Signs of Exposure/ Sent Home
  - 1200 Requiring Hospitalization
  - 12 Fatalities
  - Patients presented to over 200 Hospitals and clinics w/in hours of the incident
- St. Lukes International Hospital
  - 640 Patients on day of attack
  - 1,410 Patients in week following attack

## Communications

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### Information Sources: A Timeline

- 7:55 am Release of Sarin in Subway
- 8:16 am FD reports of Gas Explosion at a Subway Station
- 8:25 am Patient arrives by foot  
First Victim is Hospitals "best" Information Source  
Complaining of eye pain and visual darkness
- 8:40 am First Ambulance Arrives
- 8:43 am Cardiac Arrest arrives by private car
- More than 500 Victims Arrive over next one hour  
*"We suspected the victims' illness was some form of OP agent exposure.  
We were puzzled as to why it had happened in the subway"*
- 9:40 am Cholinesterase Levels reported very Low
- 9:40 am FD reports **Acetonitrile** Detected by on Scene Monitoring Equipment
- 10:30 Press Conference by Self Defense Forces Hospital "Sarin Suspected"
- 11:00 am TV News reports Police Confirmed Cause to be Sarin (No direct information from Police)
- 12:00 noon Doctors Conference held to Standardize Triage and Treatment

## EMS Response

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*"The wounded were brought from the field in wagons, carriages, ambulances, litters, and, in fact, every conveyance which could be brought into requisition."* Denney Civil War Medicine 1995

### Transportation from Scene to Hospitals

- EMTs Transported 688 Victims
- >4000 Reached Hospitals by: Foot, Taxis (25%), Private Vehicles (2/3 Cardiac Arrests)
- Unable to Obtain Hospital Availability Information, therefore, Victims Concentrated at Closest Hospital (St. Luke's)

## Victims from Tokyo Subway Sarin Attack

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### Summary of Patients treated at St Lukes Hospital

- Total = 640
- Mild = 528 (82.5%)  
Miosis, Eye pain, Dim vision
- Moderate = 107 (16.7%)  
Systemic signs e.g.. Weakness, Fasciculations, Convulsions, and Difficulty Breathing
- Severe = 5 (0.78%)  
Required Intubation and Ventilatory Support

### **Secondary Exposure to EMTs**

- No Decontamination at the Scene
- No Respiratory Protection
- Developed Symptoms During Transport
- 1,364 EMTs - 135 (9.9%) developed acute symptoms, received treatment that compromised their rescue work
- Vaporized Sarin from Victim's Clothing

### **Secondary Exposure SymptomsHospital Workers** **110/472 (23%) with Acute Poisoning Symptoms**

Eye Symptoms	66 (14.0%)
Headache	52 (11.0%)
Throat Pain	39 (8.3%)
Dyspnea	25 (5.3%)
Nausea	14 (3.0%)
Dizziness	12 (2.5%)
Nose Pain	9 (1.9%)

## **Lessons Learned from Tokyo Subway Sarin Attack**

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### **Hospital Response Problems**

- Hardware
  - Structural Deficit of Hospital Building Ventilation
  - Lack of Decontamination Facilities
- Software
  - Chemical Disaster Planning
- Transmission
  - Communication Difficulties

### **Transmission: Correcting Communication Problems**

- Organizations acted Independently with Little Communication between Organizations
- Lack of Efficient Chemical Disaster Information Network
- Poison Information Center Participation
  - During an Event Provide Acute Toxicologic Information
  - Regional Mediators of all Toxicologic Information
  - Disaster Drills
- Need Education on the Toxicological Aspects of Chemical Disasters

## Nerve Agent Poisoning Summary

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- Nerve Agents are ***BAD*** Poisons
- Effects are Similar to Organophosphate Insecticide Poisoning

### Differences Between Nerve Agents and OP Insecticides.

#### Nerve Agents have:

- Higher Potency with Greater Lethality (Lower LCT<sub>50%</sub> & LD<sub>50%</sub>)
- Extremely Rapid Onset of Effects & Aging
- Rapid Recovery After Acute Crisis (Hours)
  - Severe Poisoning has required *ONLY* 5 - 20 mg of Atropine
  - Atropine and 2PAM Infusions not Necessary

- Victims Die of Respiratory Failure
- Miosis is a CLUE to the Diagnosis in a Chaotic Mass Casualty Incident
- Learn Methods of SELF-Protection
- We are from the Poison Center, We are here to Help

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