

**John Dale Dunn MD JD**  
**Lecturer Department of Emergency Medicine**  
**Carl R Darnall Army Medical Center**  
**Fort Hood, Texas**

**Handout**

**Doctors for Disaster Preparedness Conference**  
**August 11-13, 2017**

**Chemical, Biological, Radiation and Nuclear Weaponry**

A review of the established or potential chemical, biological and radiation weapons

Basic concepts are easy to comprehend.

**Nerve agents** trigger cholinergic effects that are divided into muscarinic and nicotinic. Muscarinic effects are salivation, tearing, sweating, respiratory tract secretion and blockage, slow heart rate. The Nicotinic effect of the poison is to cause tremors, and shakes, even seizures, and nerve dysfunction, even respiratory arrest.

**Cell poisons** kill cellular metabolic processes.

**Biological agents** cause illnesses and harm from infectious agents or paralysis in the case of Botulinum toxin.

**Radioactive** emitters kill cells and tissues by alpha, beta and gamma and other ionizing emission effects. .

**Blister agents** cause inflammatory effects on living tissue by causing local injury. Mustard acts in a delayed fashion, Phosgene and Lewisite are immediately irritating and destructive.

**Pulmonary agents** such as Phosgene and Chlorine cause irritation and disruption of lung airways and tissues, causing dysfunction and damage to lungs.

**Riot control** agents are irritating and not so lethal or damaging, producing local limited effects sometimes or more serious effects in susceptible individuals.

Signs of poisoning

**Nerve agents** Nerve agents (eg, tabun [GA], sarin [GB], or soman [GD], or VX) have cholinergic nerve poisoning effects like organophosphate insecticides.

These are delivered by vapor and spray and produce muscarinic effects, small pupils, slowed heart rate, increased respiratory secretions. Severe exposures produce unconsciousness, involuntary muscle fasciculation's (nicotinic effect) convulsions from nerve dysfunctions with paralysis from excess nerve dysfunctions (also nicotinic effect). They will exhibit tremendous secretions of the respiratory tract and

sweating as well as lacrimation and salivation. Because mixed muscarinic effects can occur, muscarinic mediated bradycardia may occur or there may be tachycardia due to nicotinic effects and response to the physiologic stress. The muscle fasciculations and voluntary and involuntary seizure and paralysis/weakness developments are caused by the **nicotinic** effects.

**Incapacitating agents** (e.g. the **anticholinergic** agent, BZ [3-quinuclidinyl benzilate or QNB]) that produce in the case of BZ agitation and dry mouth rapid pulse and tremors, confusion.

## **Cyanide**

Special poison, very potent, toxic to the cell so causes a shutdown of the victim's cellular functions with further damage to all tissues. Rapid development of unconsciousness and seizures can occur in a patient that is pink rather than mottled and blue. Small exposures will show nonspecific dysfunctions and are not lethal, but victims of more serious exposures will have immediate and severe signs and symptoms, with loss of consciousness, convulsions, pink/red hue, with none of the signs muscarinic signs of nerve agents above, no secretions, small pupils, but victims may have nausea and vomiting, weakness and seizures with loss of consciousness.

An intermediate exposure to cyanide may produce a less rapid progression to the more severe nausea, dizziness, weakness, progressing to unconsciousness and convulsions, death within minutes.

**Mid-spectrum agents** – Mid-spectrum agents are chemical poisons produced by biological organisms (e.g., ricin, T-2 mycotoxins, and botulinum toxin) and are also considered chemical agents by the CDC.

**Blister agents** Mustard—period of irritation and redness, then delayed more severe damage. Lewisite and Phosgene, immediate.

The Blister agents irritate and damage the skin and moist membranes.

## **Pulmonary agents**

The Pulmonary agents are limited in use but devastating, for example Chlorine gas and other acidic gases can be used as asphyxiating agents, but depend on high concentrations and delivery that is concentrated. The effect is produced by local chemical damage to moist respiratory tract membranes, a chemical pneumonitis, producing respiratory distress and airway obstruction looking a lot like asthma.

## **Riot Control agents**

Riot control agents all have an irritating and debilitating effect on the victim, but are not damaging to the degree that will produce death or significant injury. Examples are CN, known as MACE, capsaicin, known as “pepper spray” that are irritating and unpleasant to the eyes, moist membranes and respiratory tract, but not toxic to any serious degree.

Look for common clinical findings, downwind with a sentinel case that is more severe, and effects on local

animals and insects.

- Chlorine – Yellow-green smell of chlorine
- Phosgene--Colorless gas or white cloud with odor of newly mown or musty hay, grass, or corn
- Cyanide – Odor of bitter almonds (less commonly, of burning rope or of acetylene) (only about 50 percent of people can detect this smell)
- Sulfur mustard – Yellow-brown vapor, yellow liquid, or solid that is odorless or smells like onions, garlic, mustard, or asphalt
- Tabun, Sarin, and Soman are all cholinergic nerve agents with a slight fruity odor
- VX (nerve agent) – Amber color and tasteless
- BZ – Colorless, odorless, and tasteless

### **Treatment**

Treatment for cholinergic (secretion) nerve agents is protection for providers, decontamination and supportive with no delay in administering Atropine to block the muscarinic effects and 2 PAM to remove the agent from the system nerve synapses. Many exposed victims will not require antidotes. Give atropine 2 mg IM for mild and moderate, more for severe by injector (in the appropriate setting IV atropine may be appropriate) Give the kit 600 mg of 2 PAM IM initially, IV for definitive treatment. Supportive treatment for respiratory distress and cardiac problems, intubate after atropine in severe respiratory distress and airway tract obstruction. Benzos (Ativan, Valium) for severe victims even if they haven't seized.

Evaluate effect from respiratory tract condition, respiratory secretions, not pupil size.

Supplemental medical tests Chest X-ray (pulmonary agents) blood gas and lactate for CN and nerve gas, blood acetylcholinesterase for nerve gas, Blood counts for mustard, radiation, developing anemia or hemolysis.

### **Cyanide**

If you are lucky and identify the cause early because of information or from the presentation and the pink hue, hydroxycobalamin (Cyanokit) or sodium thiosulfate and sodium nitrite (Nithiodote) are the antidotes. The former now preferred as easier and quicker. Both are IV antidotes

### **Pulmonary and Blister agents.**

Supportive care along with decontamination are the most effective action for pulmonary and blister agents. Early administration of British Anti Lewisite for Lewisite is effective.

### **RESPONSE**

#### **IDENTIFY AREA OF CONCERN**

**CREATE 1) HOT ZONE WHERE ONLY PROTECTED RESPONDERS ARE ALLOWED 2) WARM ZONE FOR DECONTAMINATION AND 3) COLD EVACUATION ZONE.**

#### **PROTECTION FOR RESPONDERS**

#### **DECONTAMINATION**

## **TRIAGE TO IDENTIFY PRIORITIES FOR TREATMENT**

### **ANTIDOTES EARLY IF INDICATED**

#### **Biological Agents**

Category A are high in virility and effect as well as potential for weaponization—Anthrax, small pox, typhus, yellow fever, hemorrhagic fevers, Tularemia, Botulinum, rickettsia, deadly viruses, plague, Category B would be resistant TB, bacterial toxins, Rickettsia. Viral encephalitides.

**Anthrax**—potent, infects skin respiratory tract, intestinal tract. Inhalation anthrax is the warfare agent—progressing to infection/shock death within hours of the time of infection. Anthrax is easy to weaponized and stable. Spores are virulent and able to survive various conditions. Anthrax is more virulent and lethal than most chemical agents, with estimates of 25 % lethality if released over a city. Cipro and Doxycycline treat Anthrax.

**Small pox**—high rates of mortality, and certainly debilitating and terror producing. Supportive treatment and vaccine circles around index cases or groups.

Most biological agents in the category B are debilitating but have a low rate of lethality, for example:

**Brucellosis**—flu like illness, 2 % lethal

**Cholera**—nausea, vomiting and profuse diarrhea, (rice water) and the bacterium is easily controlled and killed by water treatment.

**Plague**—*Yersinia pestis*, bubonic (glandular) and pneumonic (lung) Fleas are the vector, very high rate of mortality of pneumonic, pneumonic is transmissible from human to human. Bubonic to septicemic, high mortality. Not easily weaponized. Treatable with Streptomycin, Doxycycline, quinolones, Gentamycin.

**Typhoid**—systemic infection, variable, involves spleen, liver, diarrhea or constipation, lymph node, rose spots, fever prolonged, and debilitating, low mortality rate.

**Tularemia**-- rabbit fever, skin and nodular, pneumonia, Flu type illness, highly infective. The signs and symptoms of tularemia (caused by *Francisella tularensis*) vary depending on how the bacteria enter the body. Illness ranges from mild to life-threatening. All forms are accompanied by fever, described as undulant in course, which can be as high as 104 °F. Skin and intestinal tract infections not so devastating, but Pneumonic is the most serious form of tularemia. Symptoms include cough, chest pain, and difficulty breathing. This form results from breathing dusts or aerosols containing the organism. It can also occur

when other forms of tularemia (e.g. ulceroglandular) are left untreated and the bacteria spread through the bloodstream to the lungs. Treatment Strep and Gent.

## **Rickettsia**

Typhus endemic or epidemic, fever

Symptoms of these illnesses fever, headache, debilitation. Low rate of lethality, easy to weaponize and store.

Treatment Rickettsia is usually Doxycycline but other antibiotics may be effective.

## **Neurotoxins (mid spectrum, biological origin)**

**Botulinum** produced by *Clostridium Botulinum* and very potent oral or injected. Not so much when inhaled. Antitoxin essential in most cases for survival, progressive paralysis to respiratory failure is the mechanism of death. Antitoxin available from CDC.

**Ricin** is a by product of Castor Bean production. Would be released as a vapor/cloud. The likely mechanism of death is progressive respiratory failure and inflammation, and death within 48 hours. High doses required to kill,

**Saxitoxin** is a neurotoxin produced by dinoflagellates (small sea organisms) and produces a progressive neurological dysfunction with numbness and paralysis that progresses to respiratory failure.

**Mycotoxins** are produced by fungi and are potent and stable in storage. Pulmonary and skin exposures are the most damaging. Kill cells.

The notorious yellow rain is/was a mycotoxin spray that killed a few thousand in Laos.

Antitoxins are not widely available but have been made for Anthrax, Ricin and other toxins. Vaccine for Anthrax is not well liked but used by the military.

## **Bacterial toxins**

**Toxins bacterial and fungal**--delivered by spray/mist aerosol to produce lung and intestinal/food poisoning. Low lethality, high morbidity pulmonary infections and intestinal illness, fever chills headache myalgia.

Staph enterotoxin B pulmonary or intestinal/food poisoning syndromes.

## **Viruses**

**Chikungunya, Dengue**, rarely fatal except for Dengue hemorrhagic fever, however debilitating and disabling.

**Hemorrhagic fever viruses** with very high mortality (50 % plus) **Ebola**, blood and secretions contagion.

**Marburg** (epidemiology unknown, has been weaponized by the USSR).

Lesser mortality (15-25%) **Congo Crimean , Junin (Argentinian)**

Less than 5% **Rift Valley,**

**Encephalitis viruses, share** a pattern, in severe cases very debilitating with possible permanent brain damage and acute as well as residual dysfunction.

**Yellow fever virus** rapid onset and short course. Supportive care for the victims. Mortality rate high. Bad disease. Vaccine available, endemic in some areas of the world.

**Small pox** weaponized by many countries in the past, very infectious, weaponized as dry and wet preps, produces debilitating illness that starts with a short prodrome of severe flu like illness, then appearance of the pox on face, extremities, rash migrates centrally Mortality of variola major is 30 %, with high rates of death in flat and hemorrhagic variola major.

Two stockpiles of the virus in the world that are known. Last reported case 1977 due to success of vaccine program.

### **Summary of biological weapon problems**

Bio weapons are distinctly different from other forms of weapons of mass destruction, the weapons that are nondiscriminatory about their victims—bioweapons are easy to manufacture and weaponized, also easy to deliver in dry and wet forms. They are, compared to nuke and chemical, less expensive and require less technical facilities.

Bio is also more subtle in its onset and potentially more terror producing, given its mode of spread.

Bioweapons and non-explosive radiation weapons should be considered as a different problem from chemo, gas, other weapons, since they don't announce themselves and come as a disease or less dramatic effect.

Bioweaponry and radiation poisoning come in as medical/health phenomena.

Impact of bio weapons is delayed and sneaky, and there will be delays in recognition, unless the perps announce their actions.

Also problems in response—delays in diagnosis, confusion about diagnosis, often some delay before signs of disease, thus they are infectious before appearance of the disease or effect.

Vaccine and antibiotic supplies can be a critical problem.

Ineffective quarantine is always a factor because of uncooperative populations.

Anyone who was watching the Ebola outbreaks can anticipate the problems.

### **Nuclear**

Dirty radioactive bombs spray radioactive material that may produce ionizing radiation injuries to exposed populations.

Fission and Fusion devices of varying magnitude produce damage and consequences that are difficult to comprehend on a human scale. Blast and radiation are the main acute effects followed by radiation exposures from products of the blast.

Gamma and high energy ionizing radiation is the main culprit in radiation illness. Alpha and Beta particles are of less consequence because of limited penetrating power, unless injected, inhaled or absorbed through wounds, or close contact contamination occurs.

**Nuclear weapons** — the detonation of a nuclear weapon results in the tremendous release of thermal energy, gamma radiation, and alpha and beta particles. These particles can be detected in the vicinity of the detonation and in fallout miles away.

The average American gets 3 mSv (millisieverts) of ambient and 3 more diagnostic ionizing radiation exposure annually.

A chest Xray is 0.1 msv, Chest CAT scan is 7 mSv

1 gray (Gy) = 1000 milliSieverts = 100 rad,

Mortality for radiation exposure appears after 2 to 3 Gy so about 400 CAT scans of the chest or 28,000 chest x-rays.

## **TYPES OF RADIATION EXPOSURE**

- Perceived radiation injury—fear, since radiation is scary and mysterious to many.
- External, internal, partial body or whole body contamination or irradiation. Contamination produces secondary irradiation.

The skin, gonad, and eyes have the lowest threshold for damage as follows:

### •Skin –

As a general rule, if the dose received was less than 500 rad (5 Gy), the damage will be limited to erythema, severe xerosis, vesiculation, and loss of hair; eczematous changes may be permanent. Healing is delayed and may take one to two months. 500 rad (5 Gy), produces poorly healing and severe skin problems further complicate the healing process.

•**Gonads** – The pediatric gonads are exquisitely sensitive and 500 to 600 rad (5 to 6 Sv) are likely to cause permanent sterility. In young girls 500 rem (5 Sv) destroy the preformed oocytes and germinal epithelium.)

•**Eyes** are exposed when to radioactive particles 20 rad (0.2 Gy) can induce cataracts. Eye protection when working with potentially hazardous radioactive material cannot be overstated

The management is obviously dependent on location and nature of tissue involved.

Whole-body exposure can cause acute radiation syndrome.

The median lethal dose of whole-body radiation ( $LD_{50}$ ), the dose at which 50 percent of exposed patients die within 60 days is 450 rad (4.5 Gy). Several factors determine the lethality of radiation, including dose rate and distance from source, shielding to protect and medical attention available up to and including bone marrow transplants, and blood as well as prevention of infections. 50 % mortality varies from 2.5 Gy or 250 rads for access to first aid, up to 10 Gy or 1000 rad for access to tertiary care.

**Fetal exposure effects are multifarious and significant.**

**ACUTE RADIATION SYNDROME appear at more than 50 rad exposures and begin within 2 days with a latent phase up to 20 days.** — The signs and symptoms of acute radiation syndrome are related to the whole-body absorbed dose of radiation. Doses less than 50 rad (0.5 Gy) are not expected to cause acute symptoms, whereas doses of 450 rad (4.5 Gy) are lethal to 50 percent of exposed persons who have access to blood transfusions, antibiotics, and inpatient care.

Patients exposed to these doses (<200 rad [2 Gy]) can be expected to fully recover within one month, although long-term sequelae may occur.

**Latent phase of 2 to 20 days**, asymptomatic phase that follows the prodromal phase, typically occurring between 2 and 20 days after exposure. The duration of the latent phase is inversely related to the dose of radiation received. **Overt illness phase** — The overt illness phase follows a predictable pattern that usually begins with infection, anemia, and bleeding. This is followed by uncontrollable diarrhea, hypovolemia, and electrolyte disturbances. Finally, deteriorating mental status, cerebral edema, and overwhelming cardiovascular collapse occur.

The earliest lab test change effect is a fall in the absolute lymphocyte count, which begins in the first hours after exposure and continues for several weeks before returning to baseline. The fall in lymphocyte count is dose-related and the 48-hour lymphocyte count can be used to approximate the radiation dose and prognosis. In addition, radiation dose can be determined from the absolute lymphocyte count on one or two blood samples if the time from radiation exposure is known. Neutrophils, platelets, and red blood cells are affected subsequently. Neutropenia reaches a nadir at two to four weeks, when life-threatening infections can occur.

**Gastrointestinal** — The gastrointestinal syndrome typically develops within five days of initial exposure. At low doses (150 rad [1.5 Gy]), only the prodromal phase of nausea, vomiting, and gastric suppression are observed. More severe symptoms at 600 to 800 rad (6 to 8 Gy), and 1000 to 1200 rad (10 to 12 Gy) may cause death within one to two weeks from damage to the gastrointestinal tract.

**CNS syndrome** — Doses of greater than 1000 rad (10 Gy) have a near 100 percent lethality and are manifest as the central nervous system syndrome (also called the neurovascular syndrome). Children, who are particularly susceptible, may show the signs with an hour of exposure, dying with 2 to 3 days from brain damage. Adults may hang on longer, but their brain damage is still devastating and lethal.

### **Proper measures to consider for improved management of events**

1. Distinguish between Mass Casualty events, Chem weapon attacks, and bioweapons attacks.
2. For different kinds of mass casualty events, different prep and drill.
3. Better public agency planning and practice for different kinds of events, with understanding that chem is more like mass cal, bio/dirty bomb or radiation events are a different problem with a different scenario and effect.
4. Better coordination of agency activities, depending on type of event.
5. Resolution of the problem of enforcing quarantines and human transmission.
6. Develop more stock piles and better surge capacity for antibiotics, antidotes, and certainly vaccines.

### **EMERGENCY RESOURCES**

CDC – Division of Emergency Preparedness and Response

[www.emergency.cdc.gov/](http://www.emergency.cdc.gov/)

CDC Emergency Response Coordinating Group:

770-488-7100 (health professionals or government officials only)

Regional Poison Control Centers:

1-800-222-1222

CDC Coordinating Office for Terrorism Preparedness and Emergency Response: 404-639-7405

CDC Division of Bioterrorism Preparedness and Response:

404-639-0385

John Dale Dunn MD JD