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StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-.

EMS, Weapons Of Mass Destruction And Related Injury

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Last Update: August 3, 2019.

Introduction

The topic of weapons of mass destruction (WMD) and related injuries is vast. The following article provides highlights of WMD and references the importance of personal protective equipment and decontamination. In your role as a pre-hospital care provider, it is unlikely that you will know the exact agent you will need to manage. It is important to recognize patterns of symptomatology to first, protect yourself and second stabilize your patients.

Weapons of mass destruction can be summarized by the acronym CBRNE, which stands for Chemical, Biological, Radiological, Nuclear and Explosive. We will highlight key features in each of the categories.

In responding to a WMD incident, the responder must consider not only the agent in question, but also the route of dispersal as this can modify operations including personal protective equipment (PPE), a method of decontamination, and expectation to the number of possible victims.

Route of dispersal can be through aerosolization, thermal detonation, contamination of water and food supply, and even human to human contact. The ideal mode of transmission is dependent on the individual properties of each agent.

Issues of Concern

Chemical

Chemical agents are typically human-made and have been around for more than a century. These agents can be further broken down into several categories.[1][2][3][4][5]

- Blood agents such as Hydrogen Cyanide and Cyanogen Chloride are cellular asphyxiates causing death by uncoupling the electron transport chain in cellular respiration. Sodium Thiosulfate and Sodium Nitrate are the traditional antidote agents for reversal of cyanide poisoning. Clinical presentation of cyanide poisoning classically includes anxiety, hyperventilation and respiratory distress. Although “cherry red” skin is cited as a characteristic physical exam finding, this is rare. Laboratory studies on arrival to the hospital will be notable for lactic acidosis and an abnormally high venous oxygen concentration.
- Vesicants (Blister) such as Sulfur Mustard and Lewisite cause painful fluid-filled blisters to form on the skin of victims, as well as ocular and respiratory damage if inhaled. Note that there may be a delay of four to 12 hours after exposure before blisters appear making recognition in the immediate response more difficult. Decontamination is the immediate action, and further treatment is supportive including topical antibiotics, analgesia, and appropriate fluid resuscitation. Unlike thermal burns, these injuries do not require aggressive hydration. Bronchodilators and steroids may be used for pulmonary symptoms. If the primary exposure is KNOWN to be lewisite, an antidote is available – British Anti-Lewisite.

- Pulmonary agents such as Phosgene (smells of freshly mown hay) and Chlorine gases are choking agents causing predominantly respiratory symptoms and act as irritants. Presentation is notable for noncardiogenic pulmonary edema, though this is not immediate and may not be observed by prehospital providers. Treatment is the removal of the agent, and further treatment is supportive including bronchodilators as well as increased PEEP settings if intubated.
- Nerve agents such as Sarin, Soman, Tabun, VX cause the victims to exhibit the SLUDGE and "Killer B's" mnemonic and include salivation, lacrimation, urination, and defecation. Regarding immediate life threat, these agents can cause death in minutes if the antidotes of atropine and pralidoxime are not administered to reverse the "Killer B's" of bradycardia, bronchorrhea, and bronchospasm. Repeated, large doses of atropine are typically required. Severe cases reported in the literature have required up to 3000mg of atropine. Benzodiazepines may be used for seizure control.
- Incapacitating agents such as BZ (similar to Nerve Agents)
- Riot Control agents such as tear gas, pepper spray, mace. Treatment includes decontamination and supportive care.

Biological Biologic agents include bacteria, viruses, fungi, and their byproducts. Their dispersal means are similar to chemical, and proper PPE is also critical. Initial symptoms may be non-specific and "flu-like" in nature. It may be difficult to even identify if an agent is even present, let alone differentiate between different agents. The National Institute of Allergy and Infectious Disease have regularly updated sets of lists of the most dangerous biological agents. Category, A agents, are the most dangerous and are characterized by being easily disseminated or transmitted, have high mortality rates, may cause public panic or social disruption, and may require special action for public health preparedness. [6][7][8][5]**Category A Agents**

- Anthrax (Bacillus Anthracis) is a gram-positive rod. One of the most dangerous of the WMD is inhalational anthrax characterized by fever, nausea, vomiting, myalgias, and fatigue appearing one to seven days after exposure. Treatment and/or post-exposure prophylaxis (PEP) may be safely delayed 24 hours until confirmatory cultures from incident site have resulted. Treatment is with ciprofloxacin or doxycycline.
- Botulism (Clostridium Botulinum) is typically foodborne and causes a descending paralysis within six hours to ten days after exposure. Bulbar symptoms appear first and include double vision, blurred vision, drooping eyelids, slurred speech, difficulty swallowing, and muscle weakness. Death typically occurs from respiratory paralysis necessitating mechanical ventilation if not appropriately identified. Symptomatic individuals require supportive treatment as well as the antitoxin.
- Plague (Yersinia Pestis) is caused by a gram-negative bacterium that cause disease by Bubonic septicemic, and pneumonic disease in WMD, pneumonic is the more dangerous manifestation of Yersinia causing fever, malaise, and bloody sputum, leading to rapid decompensation and death if not promptly recognized and treated with antibiotics. Doxycycline or ciprofloxacin may be used for PEP coverage. Symptomatic patients require IV doxycycline, and if meningitis is suspected, chloramphenicol is added.
- Small Pox (Variola major virus) has been declared to be eradicated by the WHO in 1980. Currently, two known research laboratories (United States and Russia) have small quantities. This highly contagious virus has a latency period of 12 to 14 days. Initial symptoms are flu-like with high fever, fatigue, malaise, headache, backache, and rash. The rash starts out as flat red lesions that progress to fluid-filled pustules at the same rate. Treatment is supportive, and mortality is around 30%. A vaccine and immune globulin may be provided as PEP.
- Tularemia (Francisella Tularensis) has been weaponized by the United States and presents with its typhoidal form with symptoms of fever, non-productive cough, chest discomfort, prostration weight loss, and adenopathy. Treatment and postexposure prophylaxis are with antibiotics (gentamicin).

- Viral hemorrhagic fevers are a family of viruses including Ebola, Marburg, Dengue, Hantavirus, Rift Valley Fever, Junin, Machupo, Guanarito, and Chapare. The most well-known and deadly on this list are the Filoviruses Ebola and Marburg. They both cause multisystem organ failure following a flu-like illness as well as the characteristic hemorrhage. Lethality ranges from 50% to 90%.

Other Biological Weapons

Ricin is derived from the castor bean plant. This toxin in weaponized form would typically be inhaled or ingested leading to airway edema and necrosis or gastrointestinal hemorrhage followed by necrosis. Differentiation of ricin poisoning and sepsis can be very difficult as both may present similarly. Treatment is supportive.

Q Fever (Coxiella Burnetti) manifests after a 10 to 40 day incubation period with undifferentiated fever, headache, fatigue, and myalgias. What makes this agent so dangerous is that it can persist on inanimate objects for months and only requires a single organism to cause infection. Treatment is with tetracycline or doxycycline.*Radiologic/Nuclear Weapons*Radiologic and nuclear weapons have been the subject of fear and controversy over the past decades. What is most important for the first responder is proper PPE, decontamination, and understanding the difference between exposure and contamination.

Prevention of contamination can be summed up by remembering the three tenets of time, distance, and shielding. Time refers to how long the victim was exposed to the source; distance is how far away the victim was from the source, and shielding is what PPE or other barriers were in place to lessen the radiation burden to the victim.Exposure refers to how close the victim was to the source of radiation, whereas contamination is when the victim comes in physical contact with the radiation source and subsequently continues to be exposed and may expose others. Contamination may be external or internal depending on the material being swallowed, absorbed or entering wounds in the skin. Decontamination will be discussed below.

It is important to remember that radiologic contamination does NOT change your treatment priorities. Radiation itself is not an immediate emergency. All first responders should don appropriate PPE (gloves, respiratory protection) but should not delay lifesaving treatment due to concern for contamination. The Heath Physics Society consensus statement supports this noting that it would be unlikely for an improvised explosive device with a radiologic component to disperse sufficient radioactive material to pose an immediate health hazard to first responders. Universal precautions used for typical infection control processes are sufficient to protect health care workers from radioactive material. [9]*Explosive Weapons*

Explosive weapons come in two general categories. High-order explosives undergo detonation and cause high-pressure blast waves which cause the primary blast injuries. High order explosives include TNT, dynamite, and C4. Low-order explosives undergo degradation and lack the blast wave and include gunpowder, fireworks, and pyrotechnics. These low-order explosives, while still potentially deadly, lack the over pressurization and do not present with primary blast wave injuries. Explosive effects include incendiary effects which occur in the immediate vicinity of the explosion. As described previously, each compound has different incendiary potential. While low-order explosives produce less heat, the temperature is sustained for a longer period of time and the potential for fires and burn related injuries is higher relative to high-order explosives.

These devices may be augmented to include more destructive pieces such as ball bearings, using PVC piping due to its radiolucency, or even agents from other categories in order to further the destructiveness of the weapon. In general, these weapons are meant to cause as much fear and destruction as possible. This presents a dilemma for the healthcare provider as these patients can present with multisystem trauma necessitating stabilization of the ABCs and rapid transport to the closest appropriate trauma center.

Blast injuries are divided into four categories:

- Primary direct effect of blast overpressure on tissue of which pulmonary barotrauma is the most common fatal primary injury. These patients can develop pneumothoraxes, and noncardiogenic pulmonary edema/ARDS. Other hollow organ injuries include ruptured tympanic membranes or gastrointestinal tract injury

- Secondary: Caused by flying objects propelled by the explosion. This may include fragmentation of the device itself, or shrapnel from materials actually added to the device.
- Tertiary: Caused by blast wind that throws the victim against objects
- Quaternary: Anything not included in the above categories including burns and crushing.

Typically, in an open environment, there are fewer injuries associated with the over-pressurization of the blast wave, however, penetrating trauma is often of greater concern. In a closed environment (subway car, bus, etc.) the rates of pressure-related injuries are higher as the blast wave cannot decay and is reflected around the enclosed space.[10]

Clinical Significance

Decontamination and PPE

Decontamination is the first, and one of the most important steps when evaluating and treating a victim of a WMD attack. Which type of decontamination you will choose will be dependent on your level of training, nature of the exposure, and the availability of resources.[11][12]*Emergency Decontamination*Emergency decontamination is the process of removing life-threatening agents as quickly as possible with or without the establishment of a decontamination corridor. This may be as simple as removing outer and all garments to washing with a safety shower or fire hose fog stream.*Gross and Mass Decontamination*In the prehospital world, patients will typically undergo multiple rounds of decontamination starting with gross mass decontamination with which ambulatory victims will walk through fog streams sprayed by fire engines. This is the quickest but least thorough of all types.*Technical Decontamination*Technical decontamination is a more thorough decontamination for providers and equipment. This is to ensure provider safety and to minimize further contamination.*Definitive Decontamination* Definitive decontamination is a more resource-intense process in which both ambulatory and non-ambulatory victims are put through adecontamination corridor and thoroughly washed with soap and water. HAZMAT teams, Hospital Emergency Response Teams (HERT,) or other trained staff wearing PPE typically undertake these processes.

Disaster Preparedness

The Disaster Paradigm[10]

The Disaster Paradigm is an all-hazards model that may be applied to any mass casualty disaster and is a useful framework to describe preparation and response for WMD attacks. This was developed by the American Medical Association's National Disaster Life Support program. The model uses the word disaster to outline stages of any mass casualty incident response. The components are as follows:

- Detection – Recognize that the situation will overwhelm the available resources of the provider arriving on scene first. Often the full scope of the WMD attack will not be identified immediately and will develop over time.
- Incident Command – Initiate the National Incident Management System Incident Command System early! This will provide the flexibility of response, clear leadership, and authority structure, and increase available resources.
- Scene security- Assess scene safety, access, and don PPE as necessary.
- Assess hazards – Be aware of other potential threats such as secondary devices, radiologic or chemical agents.
- Support – Initial responders may be tasked with the first needs assessment with regards to hospital readiness, additional EMS units, medical direction, HAZMAT response, fire/rescue, and logistic support.
- Triage/treatment- Initiate MCI triage with a standard protocol.
- Evacuation – Evacuation is a complex process requiring evacuation from the scene, coordination of resources, and potentially gross decontamination prior to leaving the scene.

- Recovery – Begin the process at the time of the response. Prepare for physical and psychological needs of victims, responders, and families.

Questions

To access free multiple choice questions on this topic, click here.

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Bookshelf ID: NBK441954 PMID: 28722983