

Chapter 35

Biologic and Chemical Terrorism: Surveillance and Response

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Scope of Chapter

- Weapons of mass destruction
- Common biologic and chemical agents
- Surveillance for deaths from biologic and chemical terrorist attacks
- Practical issues in dealing with fatalities caused by biologic and chemical agents
- Biosafety recommendations for biologic and chemical events

Weapons of Mass Destruction

Weapons of mass destruction are defined as “any destructive device that is designed or intended to cause death or serious bodily injury through the release, dissemination, or impact of toxic or poisonous chemicals, or their precursors; any weapon involving a disease organism; or any weapon that is designed to release radiation or radioactivity at a level dangerous to human life.”¹ These agents can potentially cause large numbers of casualties over a period varying from a few minutes to weeks or months. Weapons of mass destruction were principally developed or adapted for military purposes. For example, during World War II, outbreaks of bubonic plague occurred in the Chinese towns of Chussien, Ningpo, and Kinhwa, each after a Japanese plane dropped a load of wheat grain and rice admixed with numerous fleas. Organisms with the microscopic features of *Yersinia pestis* were identified in some of the material; however, the organism itself was never cultured from the samples. These cities had never reported plague.² Toxic chemical agents were developed and used during trench warfare in World War I, and nuclear weapons were developed and deployed during World War II.³

Although the 1925 Geneva Protocol forbids the use of chemical and bacteriological agents in war,⁴ some nations still have stockpiles and production facilities capable of producing many of these weapons. Reportedly, 9 nations have nuclear weapons, 27 have chemical weapons, and 19 have biologic weapons.⁵ Some biologic weapons can be produced in a civilian setting by using equipment for making yogurt, yeast, or beer,⁶ and the biologic agents themselves often are easily accessible. For example, in May 1995, a laboratory technician in Ohio ordered *Yersinia pestis* cultures from a Maryland biomedical supply firm by using a credit card and a fake letterhead.⁷

Although reports of chemical and biologic terrorism are rare, the release of sarin into the Tokyo subway system, the deliberate contamination with *Salmonella* of salad bars in Oregon, and the recent

Table 35-1

Chemical Agents

Nerve agents <ul style="list-style-type: none">■ Tabun (ethyl N,N-dimethylphosphoramidocyanidate)■ Sarin (isopropyl methylphosphanofluoridate)■ Soman (pinacolyl methyl phosphonofluoridate)■ GF (cyclohexylmethylphosphonofluoridate)■ VX (o-ethyl-[S]-[2-diisopropylaminoethyl]-methylphosphonothiolate)
Blood agents <ul style="list-style-type: none">■ Hydrogen cyanide■ Cyanogen chloride
Blister agents <ul style="list-style-type: none">■ Lewisite (an aliphatic arsenic compound, 2-chlorovinylchloroarsine)■ Nitrogen and sulfur mustards■ Phosgene oxime
Heavy metals <ul style="list-style-type: none">■ Arsenic■ Lead■ Mercury
Volatile toxins <ul style="list-style-type: none">■ Benzene■ Chloroform■ Trihalomethanes
Pulmonary agents <ul style="list-style-type: none">■ Phosgene■ Chlorine■ Vinyl chloride
Incapacitating agents <ul style="list-style-type: none">■ BZ (3-quinuclidinyl benzilate)
Pesticides, persistent and nonpersistent
Dioxins, furans, and polychlorinated biphenyls (PCBs)
Explosive nitro compounds and oxidizers <ul style="list-style-type: none">■ Ammonium nitrate combined with fuel oil
Flammable industrial gases and liquids <ul style="list-style-type: none">■ Gasoline■ Propane
Poisonous industrial gases, liquids, and solids <ul style="list-style-type: none">■ Cyanides■ Nitriles
Corrosive industrial acids and bases <ul style="list-style-type: none">■ Nitric acid■ Sulfuric acid

Adapted from Centers for Disease Control and Prevention¹¹

distribution of anthrax-contaminated letters to several points in the United States illustrate the threat of these types of agents.⁸⁻¹⁰

Forensic pathologists therefore should be knowledgeable about potential terrorist agents and should develop appropriate response plans. Medical examiners and coroners have a role to play in both surveillance for unannounced terrorist attacks and the response to known terrorist events.¹¹⁻¹³ Preparations for surveillance for and response to biologic and chemical terrorist attacks could be considered in the same context as preparedness for industrial chemical accidents or an outbreak of an emerging infectious disease since these events would stress a medical examiner/coroner system in a similar manner. Although large quantities of explosives and nuclear devices also have the ability to cause mass casualties,¹⁴ this chapter will focus only on biologic and chemical agents.

Biologic and Chemical Agents

To prepare public health agencies for terrorist attacks, the Centers for Disease Control and Prevention (CDC) has developed a list of critical biologic and chemical agents.¹¹ The chemical agents that might potentially be used by terrorists range from known warfare agents to several toxic industrial chemicals (Table 35-1). High priority for public health preparedness is given to those agents already known to be used for chemical warfare, chemicals readily available to terrorists, chemicals that can cause high mortality and morbidity, and chemicals that require special preparedness in the public health community. The toxicity of a chemical agent is a function of its concentration in the environment and the time that a person is exposed.

The biologic agents are classified by the CDC into categories A, B, and C. Category A biologic agents (Table 35-2) pose a high-level risk to national security because they are easily disseminated or transmitted person to person, cause high mortality, might cause public panic and disruption, and require special preparedness in the public health community. Category B agents (Table 35-3) are the second highest priority for preparedness. They include agents

that are moderately easy to disseminate and cause low mortality and moderate morbidity. Category C agents (Table 35-4) are the third highest priority. These agents are emerging pathogens that could be developed for terrorist purposes because of ready availability, ease of production and dissemination, and the potential for high morbidity and mortality. Biologic terrorism agents might be largely unfamiliar to forensic pathologists because sporadic fatalities caused by these organisms are rare. Table 35-5 illustrates the characteristics of the Category A biologic agents.

Surveillance for Deaths from Biologic and Chemical Terrorist Attacks

Medical examiners have an important role to play in surveillance for bioterrorist events because they might see fatalities that have not been seen by other health care providers. It is common for persons who die from infectious diseases or poisoning to die at home.^{15,16} Even persons who present first to other physicians, emergency rooms, or hospitals might fall under medical examiner jurisdiction if they die suddenly and unexpectedly without a clear diagnosis. For example, in 1993, medical examiners were the first to recognize an outbreak of a fatal respiratory disease later identified as hantavirus pulmonary syndrome, a disease with symptoms that can mimic bioterrorism-related illness.¹⁷ Coroners and medical examiners also have played an important role in recognizing outbreaks and cases of fatal plague^{18,19} and malaria.²⁰

Autopsies are the best way to identify the agent-specific cause of deaths due to infections or toxins. For example, in 1999, medical examiners performed autopsies during the outbreak of West Nile encephalitis in New York, which defined the pathologic characteristics of the disease.²¹ In 2001, autopsies performed by medical examiners confirmed inhalational anthrax as the cause of death in fatalities associated with the intentional release of anthrax spores.^{22,23} Similarly, in 1979, autopsy pathologists recognized fatal cases of inhalational anthrax that were caused by an accidental discharge from a Soviet bioweapons laboratory.^{24,25} In Illinois, medical

Table 35-2

Category A Biologic Agents

- *Variola major* (smallpox)
- *Bacillus anthracis* (anthrax)
- *Yersinia pestis* (plague)
- *Clostridium botulinum* toxin (botulism)
- *Francisella tularensis* (tularemia)
- Filoviruses, including Ebola and Marburg hemorrhagic fever
- Arenaviruses, including Lassa (Lassa fever), Junin (Argentine hemorrhagic fever), and related viruses

Adapted from Centers for Disease Control and Prevention¹¹

Table 35-3

Category B Biologic Agents

- *Coxiella burnetii* (Q fever)
- *Brucella* species (brucellosis)
- *Burkholderia mallei* (glanders)
- Alphaviruses, including Venezuelan encephalomyelitis, and eastern and western equine encephalomyelitis
- Ricin toxin from *Ricinus communis* (castor beans)
- Epsilon toxin of *Clostridium perfringens*
- *Staphylococcus enterotoxin B*
- *Salmonella* species
- *Shigella dysenteriae*
- *Escherichia coli* O157:H7
- *Vibrio cholerae*
- *Cryptosporidium parvum*

Adapted from Centers for Disease Control and Prevention¹¹

Table 35-4

Category C Biologic Agents

- Nipah virus
- Hantaviruses
- Tickborne hemorrhagic fever and encephalitis viruses
- Yellow fever virus
- Multidrug-resistant *Mycobacterium tuberculosis*

Adapted from Centers for Disease Control and Prevention¹¹

Table 35-5

Characteristics of Category A Biologic Agents

Disease	Incubation Period	Duration of Illness	Mortality	
Inhalation Anthrax	1-6 days	3-5 days	100% Untreated	40% Treated
Botulism	6 hours-10 days	24-72 hours	Outbreak: 1st patient: 25% Subsequent cases: 4% Overall: 5%-10%	
Tularemia	1-21 days	2 weeks	33% Untreated	<4% Treated
Pneumonic Plague	2-3 days	1-6 days	40%-70% Untreated	5% Treated
Smallpox	7-17 days	4 weeks	Variola minor: <1% Variola major: 20%-50%	
Viral Hemorrhagic Fever	4-21 days	7-16 days	53%-88%	

Adapted from Centers for Disease Control and Prevention¹¹

examiners identified the cause of death in persons who were poisoned by acetaminophen intentionally adulterated with cyanide.²⁶

A medical examiner-based surveillance model for bioterrorism mortality has been developed in New Mexico.²⁷ In this model, surveillance for bioterrorism mortality is conducted within the larger framework of surveillance for deaths of public health importance. The model uses a set of antemortem symptoms (eg, fever) and pathologic syndromes (eg, community-acquired pneumonia/diffuse alveolar damage) for case identification. Cases meeting selected pathologic syndrome criteria are reported to the Department of Health. As anticipated, the use of uniform criteria for autopsy performance, development of case definitions, and case reporting to public health authorities enhanced surveillance, which in turn should increase the likelihood of recognizing future deaths related to bioterrorism. Death investigation information regarding antemortem symptoms, such as “flu-like”

symptoms and “fever with respiratory symptoms,” was predictive of infectious diseases. This protocol demonstrated that surveillance for bioterrorism-associated mortality within the broader context of mortality-based surveillance for infectious diseases of public health importance is feasible. Such protocols should be considered for implementation in other medical examiner and coroner offices.

Another surveillance model currently being tested in the medical examiner offices in King County, Washington, and Fulton County, Georgia, involves the sharing of daily medical examiner case logs with the local public health agency. This surveillance activity includes review of the decedent’s demographic information and the cause and manner of death by health department staff to determine if the mortality data reveal any unusual information. Health department staff compares these data with data from other public health surveillance activities to assess the population’s health status.

In addition to conducting specific surveillance activities, each medical examiner should be familiar with the pathologic findings characteristic of the conditions caused by the critical bioterrorism agents. When a suspicious case or a death is encountered, the medical examiner should report the case to the public health system according to established statutes and reporting protocols. If no such protocol exists, the medical examiner should contact their local public health department to identify the appropriate public health contacts for biologic and chemical terrorism surveillance and response.

Medical examiners should establish and maintain routine interaction and information exchange with their local health departments to ensure that critical information is available as needed. Public health departments can provide information on notifiable conditions, reporting procedures, and emerging public health threats. Additionally, some medical examiner jurisdictions collaborate with the public health system for microbiologic and other laboratory testing to support death investigation and certification.

Practical Issues in Dealing with Fatalities Caused by Biologic and Chemical Agents

Federal and state agencies, academic institutions, and the military are continuing to prepare guidelines to address biologic and chemical terrorism preparedness and response. The plans typically address surveillance, emergency response, and procedures for handling multiple fatalities. The guidelines below have been extracted from personal involvement by the authors in some of these working groups. As definitive reports are published, readers should use the information to supplement or replace these guidelines.

Risk assessment is an uncertain process. Various hypothetical chemical and biologic terrorism scenarios have been created in which the numbers of fatalities range from dozens to tens of thousands, depending on the agent and the release site. The numbers of fatalities could exceed the capacity of a well-prepared death investigation system.

A chemical or biologic terrorist event is likely to differ depending on the agent. Some agents, such as toxic chemicals, might produce an obvious crime scene; whereas the crime scenes associated with the release of other agents, such as biologic pathogens, might not be recognized initially, only becoming evident several days later as the ill victims seek medical assistance or the dead are discovered.

- Handling fatalities caused by certain biologic and chemical terrorism agents might create occupational hazards for death investigators and pathologists. Adequate preparation covering personal protective equipment, policies and procedures, and facility design can protect these workers.
- With a large-scale terrorist event, the medical examiner/coroner worksite might need to be evacuated, or facilities might be rendered unusable, having no power or conventional communications. Therefore, medical examiner/coroner offices should develop backup plans for conducting investigations and autopsies at an alternate site.
- All fatalities resulting from a terrorist attack are homicides. The medical examiner/coroner should evaluate the circumstances of the event and decide which cases require a full autopsy. In general, the medical examiner/coroner should perform as many autopsies as are feasible, given the constraints of case volume and biosafety. These homicide autopsies should be sufficiently complete to meet medicolegal standards.
- The Incident Command System (ICS) is the personnel management architecture currently followed by response agencies in emergency responses. If a terrorist attack resulting in fatalities were to occur, medical examiners and coroners would need to function within the organizational hierarchy created by this system. The ICS assigns authority and ensures that personnel operate safely and in compliance with applicable laws, regulations, and standards, and that resources are used efficiently.²⁸ Before an event, the medical examiner and coroner should contact their local health department and criminal justice agency to identify their contacts during an emergency response so they are aware of their role in an ICS-managed response.

Biosafety Issues for a Chemical Event

Areas contaminated by chemical agents are classified into various zones depending on the degree of contamination. The “hot zone” is defined as the area contaminated by the chemical agent. Surrounding it is a buffer area known as the “warm zone.” Decontamination usually takes place at

the interface of these zones. The “cold zone” surrounds the warm zone and is a contamination-free area; access to the cold zone is controlled, and only authorized personnel may enter.

Personal Protective Equipment

Personal protective equipment (PPE) for chemical agents is categorized into 4 levels.^{29,30}

- Level A: Fully encapsulating chemical suit used with self-contained breathing apparatus (SCBA). These units cost approximately \$10,000 and require considerable maintenance and training.
- Level B: Single or 2-piece chemical suit (non-encapsulating), with or without integral face shield, used with SCBA. Note: Firefighter turnout gear, ie, standard issue fire protection worn over garments, provides similar protection to a level B suit if used with SCBA.
- Level C: Splash-type chemical suit with cartridge-type air purifying respirator. These suits cost approximately \$200 and require minimal training.
- Level D: Simple overgarments for regular clothing (eg, laboratory coat).

In a chemical event, the incident commander determines the correct level of PPE to use in each of the zones. Levels B and C satisfy most circumstances that require the presence of death investigators. Level B should be used in the hot zone if the agent is still present and is a risk to personnel. Level A and B suits can be hot to wear and have limited visibility. The air supply for SCBA lasts about 30 to 45 minutes, including suit donning and decontamination. An air supply hose can increase the available time but limits mobility. Level C is appropriate for most circumstances, depending on the agent, ranging from body decontamination to autopsy.²⁹ The respirator cartridges for level C suits last approximately 3 hours. Because PPE can be expensive, a more economical arrangement could be for medical examiners/coroners to arrange access to equipment provided by a local hazardous materials (HAZMAT) team (personnel trained to respond to and manage emergencies involving hazardous materials).

Decontamination

Decontamination is the process of removing or chemically degrading an agent on the body surface to a level that poses little or no risk to others in proximity to that surface.³¹ Most of the liquid chemical terrorism agents, except for mustard agents, are soluble in water. Gaseous terrorism agents (eg, cyanide, phosgene) require less body surface decontamination. Nevertheless, chemical vapors might remain trapped in clothing and pose an inhalation risk for persons handling the body.

Decontamination will remove and destroy most of the chemical agent; hence, any sampling for evidence or toxicologic testing must be done before this procedure. Chemical decontamination should be done only under the guidance of a HAZMAT team director, while wearing appropriate PPE. Standard HAZMAT procedures dictate that a suited-up backup team should be available to evacuate other team members. A “buddy system” should also be used.

Specific Suggestions for Handling Bodies at a Chemically Contaminated Scene

- Document and photograph the scene.
- Place waterproof identification tags or bracelets on the bodies.
- Collect as evidence any loose items that might be lost transporting the body to the edge of the hot zone.
- Bring the body to the edge of the hot zone in an open wire-mesh body litter.

- Document and remove personal belongings, clothing, and evidence. Place clothing and other potentially contaminated evidence in labeled sealed containers. Paint cans are suggested; they are easily available, unbreakable in transit, and “contain” volatile chemicals.
- First, wash the body surface with bleach (which hydrolyzes chemical bonds and speeds the degradation of some agents) and soap solution to remove any surface contamination. The use of 0.5% bleach solution is recommended for use on live victims. Higher concentrations (5.0%) can be used on dead bodies. However, use of the 0.5% solution is recommended to avoid inadvertent use of the higher concentration on survivors.^{29,32}
- Apply water in copious quantities at low pressure to avoid agent dispersment. (Mustard agent is an oily substance and requires additional detergent and scrubbing to remove.)
- Use vinyl-free body bags to transport bodies to the morgue facility. (Environmental Protection Agency regulations prohibit vinyl plastic from being incinerated/cremated without appropriate scrubbers to prevent emissions.)

Planning for Death Scene Investigation

All death investigation jurisdictions should review their own mass fatality plan and incorporate a section on handling fatalities from chemical contamination. If possible, medicolegal death investigators should examine bodies at the scene, as would happen in any other homicide. *However, sending untrained personnel into a hot zone — even in the correct equipment — is not prudent.* One solution, adopted in Maryland, is to train forensic investigators and medical examiners in basic HAZMAT procedures. These programs are available from local HAZMAT teams or from commercial trainers. The HAZMAT technicians are not trained in crime scene processing and cannot adequately substitute for forensic investigators unless they receive additional training. It is unlikely that the local law enforcement agency will have homicide detectives or crime scene personnel who are HAZMAT-trained. The Federal Bureau of Investigation has some HAZMAT-trained personnel, but the response time for these resources might delay the crime scene evaluation and processing. Not all death investigation agencies will desire or be able to train personnel to operate in a hazardous environment. If appropriately trained personnel are not available, arrangements must be made with HAZMAT or law enforcement agencies and prosecutors to ensure that hazardous crime scenes involving fatalities can be appropriately processed. For example, death investigators can view a chemically contaminated crime scene via video cameras operated by HAZMAT personnel.

Specific Suggestions for Performing Autopsies on Chemically Contaminated Bodies

Out-gassing of volatile chemical agents from body cavities is theoretically possible. For example, hydrocyanic gas has posed a risk to autopsy prosecutors examining cases of cyanide poisoning.³³ However, many agents are so rapidly fatal that no significant reservoir is likely to exist in any of the body cavities.

- Autopsy staff should wear Level C PPE.
- Create a well-ventilated area with a linear flow away from personnel (eg, via use of fire department smoke extractors).
- Wash the body a second time before standard autopsy procedures.
- Rotate and monitor staff throughout the examinations. The presence of a paramedical team to perform pre-entry baseline blood pressure, temperature, respiratory rate, and electrocardiogram on autopsy personnel is part of a HAZMAT team’s standard procedures.

- Mutual aid agreements with other agencies to share experienced personnel and limited resources become critical in these events.

Recommendations for Storing Contaminated Bodies

Refrigeration is still the best method of storing contaminated bodies. However, refrigerators are a closed space and likely have limited ventilation. If contaminated bodies are refrigerated, it is appropriate to wear PPE when entering these areas. Chemical monitors should be placed inside and outside of these units.

Biosafety Recommendations for a Biologic Event

Surface decontamination before autopsy makes little sense because biologic agents are present throughout the tissues. Consequently, PPE and autopsy policies and procedures, including agent-specific vaccination, antibiotic prophylaxis, and autopsy facility design, become important in handling fatalities from biologic agents. Biosafety guidelines for infectious agents can be found in chapter 36.

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Web Sites

CDC Medical Examiner and Coroner Information Sharing Program, Links:

www.cdc.gov/epo/dphsi/mecisp/links.htm

CDC Smallpox Response Plan and Guidelines:

www.bt.cdc.gov/agent/smallpox/response-plan/index.asp

Disaster Mortuary Response Teams:

<http://www.dmort.org/>

Edgewood Chemical Biological Center (ECBC):

www.apgea.army.mil/RDA/ecbc/

Metropolitan Medical Response System Field Operations Guide:

<http://www.oep.dhhs.gov/CT Program/Response Planning/response planning.html>

National Association of Medical Examiners:

www.thename.org