# Chapter 20

# USE OF BIOLOGICAL WEAPONS

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## INTRODUCTION

During the Persian Gulf War (1990–1991), the United States and her coalition partners were faced with the credible and realistic threat that weapons of mass destruction, including biological agents, might be used by Iraq against allied forces. It is now known that Iraq had actually put offensive biological agents into several weapons systems for delivery (see Chapter 18, Historical Overview of Biological Warfare). These revelations, combined with the fact that terrorist groups such as the Aum Shinrikyo in Japan have sought to produce biological agents, have catapulted the United States into an era where the use of biological warfare agents against either our military forces or against civilian populations by terrorists is a possibility that we cannot ignore.

Defending against these agents requires us to understand how an adversary might use them. Biological agents must be considered in terms of an evolving world, where advances in modern technology and weapons delivery systems (eg, long-range cruise missiles with multiple warheads) have overcome some of the earlier physical limitations. A biological warfare agent need no longer be highly lethal to be effective, for incapacitation and confusion may be all the disruption necessary to cause the intended effects. Biological weapons may also be used in combination with other types of weapons, or to add to the disruption produced by conventional weaponry. Finally, it would appear from the way conflict is evolving that nonconventional or terrorist use of biological agents is becoming more rather than less likely. The method for delivery of biological warfare agents may be as simple and inconspicuous as attaching an off-the-shelf spray device to a car, truck, boat, or airplane which appears harmless and normal to all who might observe the delivery vehicle.

Since initial symptoms resulting from a biological warfare agent may often be indistinguishable from those produced by endemic infections, a biological weapon may be capable of overcoming a military force before the presence of the agent is even suspected. When one member of a unit falls victim, others may still be incubating the disease. Troops deployed to foreign lands are at greater risk for exotic endemic disease agents, since they may lack natural immunity. Therefore, a biological warfare attack may not even be suspected after the first casualties have presented to medical personnel. Finally, the psychological and demoralizing impact of the sinister use of a lethal infection or toxin cannot be underestimated.

Many biological agents, including bacteria, viruses, and toxins, can be used as biological weapons. The respective chapters in this textbook contain detailed discussions of these pathogens and toxins as biological weapons.

## REQUIREMENTS FOR AN IDEAL BIOLOGICAL WARFARE AGENT

Although many pathogens and toxins cause disease or intoxication of humans, relatively few would actually be effective if employed as biological weapons (Exhibit 20-1).

For a number of reasons, some that might be useful on a small scale, such as an assassination weapon or a terrorist weapon, would normally not be applicable on a large scale. The key factors that make a biological pathogen or toxin suitable for a large-scale biowarfare attack include: *(a)* availability or ease of production in sufficient quantity; *( b)* the ability to cause either lethal or incapacitating effects in humans at doses that are achievable and deliverable; *(c)* appropriate particle size in aerosol; *(d)* ease of dissemination; *(e)* stability (while maintaining virulence) after production in storage, weapons, and the environment; and (f) susceptibility of intended victims with nonsusceptibility of friendly forces.

We will examine each of these requirements for a suitable agent in greater detail below. However, healthcare providers and medical planners must always remember that biological agents could be used in a wide variety of scenarios. What may look like an ordinary outbreak of diarrheal disease early in a deployment could be, instead, a

**EXHIBIT 20-1**
**POSSIBLE BIOLOGICAL WARFARE AGENTS**

**Bacteria**

- *Bacillus anthracis* (anthrax)
- *Yersinia pestis*(plague)
- *Francisella tularensis*(tularemia)
- *Brucella* species (brucellosis)
- *Coxiella burnetii* (Q fever)

**Viruses**

- Variola virus (smallpox)
- Equine encephalitis viruses (viral equine encephalitides)
- Arenaviruses, bunyaviruses, filoviruses, flaviviruses (hemorrhagic fevers)

case of sabotage of food or water supplies with an infectious agent. This type of operation might even be carried out by enemy special forces against our soldiers in garrison at home or deep behind friendly lines.

**Toxins**

- Staphylococcal enterotoxin B
- Ricin
- Botulinum toxins
- Trichothecene mycotoxins
- Saxitoxin

### Availability or Ease of Production

Many replicating agents (bacteria and viruses) can be produced in large quantities with modern fermentation and viral production technologies. Some toxins, like ricin, are widely available because their source in nature is ubiquitous and the process necessary to harvest the toxin is technically straightforward. On the other hand, some replicating agents are very difficult to grow in quantity or to a high-enough titer, and many toxins are produced in nature in such low quantities that harvesting them is impractical (shellfish toxins are a good example). Some of the rare toxins, like saxitoxin, could be used on a very limited scale to target one or a few individuals but currently could not be used as weapons of mass destruction. Some of these limitations could possibly be overcome by future adversaries, who might use recombinant techniques to amplify production of some of these compounds. To be adequate weapons for large-scale use, some toxins of low toxicity or high $LD_{50}$ (ie, the dose that is lethal to 50% of the exposed population) would have to be used in ton quantities to be effective over a wide area—which limits their potential utility. This subject is discussed in greater detail in Chapter 30, Defense Against Toxin Weapons (see Figure 30-1).

### Incapacitation and Lethality

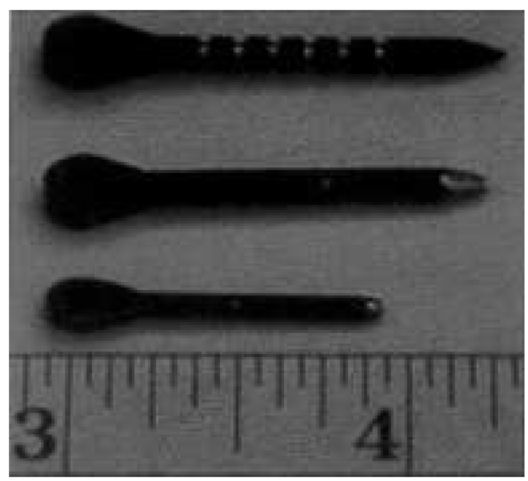
Biological warfare agents are likely to be selected for their ability to either incapacitate or kill the human targets of the attack. A biological warfare agent does not necessarily have to be lethal to be useful as a military weapon. An agent such as Venezuelan equine encephalitis (VEE) virus could render entire military units mission-ineffective by incapacitating large numbers of unit personnel. If one of an adversary’s aims is to overload our field medical care systems, an incapacitating agent such as VEE virus might be chosen preferentially to a lethal biological agent. VEE casualties may require hospitalization, tying up beds and medical resources needed for the care of battle-injured soldiers.

If lethality is desired, agents such as *Bacillus anthracis* (anthrax); the viruses that cause Ebola hemorrhagic fever, Marburg disease, and

Crimean-Congo hemorrhagic fever; or the plague bacillus, *Yersinia pestis*, might be used against U.S. forces. Inhalational anthrax, pneumonic plague, and certain viral hemorrhagic fevers have high case-fatality rates once infection is established in nonimmune hosts. Viruses may be particularly attractive as biological warfare agents because specific treatments are not available for many of them. Agents that require low doses to produce their intended effects whether lethality, incapacitation, or intoxication would, for logistical and tactical reasons, have greater utility as biological weapons.

Although in general a shorter incubation time to onset of deleterious effects is desirable, this characteristic would vary according to the aims of the aggressor. Very short incubation periods might be more useful in a tactical setting, whereas longer incubation times would work to the advantage of the terrorist, assassin, or special forces unit, to enable them to escape prior to the onset of the effects of the attack.

Very few biological agents are immediately lethal. Some of the most toxic toxins, such as saxitoxin, are available only in small quantities but an adversary could use these as assassination or antipersonnel weapons. Certain penetrating devices designed to be used with such toxins, such as flechettes, have been developed in the past (Figure 20-1).




An ideal biological weapon would also cause disease or intoxication when inhaled, as the most likely and effective mode of dissemination of a biological warfare agent is by aerosolization of the toxins or bacterial or viral organisms. The characteristics of such aerosols are discussed further below.

**Appropriate Particle Size in Aerosol**

Biological agents may enter the human body via several routes:

- entering the lungs as an aerosol (the inhalational route),
- being ingested in food or water (the oral route),
- being injected through the skin into the body (the percutaneous route), and
- being absorbed through the skin

or placed on the skin to do damage to the integument (the dermal route).

**Fig. 20-1.** Sharp flechettes designed for antipersonnel purposes can be used with either chemical or biological agents. The agent can be applied to the flechette's exterior grooves, or the flechette can be drilled and filled with either a liquid or a dry agent. These types of weapons would not be permissible under the Biological Weapons Convention; however, an adversary of the United States might ignore such restrictions, as has occurred in the past. Reprinted from van Keuren RT. *Chemical and Biological Warfare, An Investigative Guide*. Washington, DC: Office of Enforcement, Strategic Investigations Division, US Customs Service; 1990: 87.

The inhalational or aerosol route of entry into the body is by far the most important to consider when planning defenses against biological warfare attacks. An ideal biological warfare agent would be of a particle size that would allow it to be (1) carried for long distances by prevailing winds and (2) inhaled deeply into the lungs of the unsuspecting victims. The size range of particles that meets both of these conditions is 1 to 5 µm in diameter. Particles larger than this would either settle out onto the ground or be filtered out in the upper respiratory tract of those who inhale them. Particles in this size range are invisible to the human eye; thus, a cloud of such particles would not generally be detected by those attacked, even if such a cloud were to be carried through their position. An adversary designing a biological weapon would therefore seek to produce such a small particle size, and would require the equipment and technology to do so. From the standpoint of military medical personnel, the lack of a fielded standoff (ie, remote) detection capability for such a biological "cloud" makes clinical and laboratory diagnostics critical for early diagnosis of the initial casualties of a biological attack. The separate issues of detection and medical diagnosis will be addressed later in this chapter.

### Ease of Dissemination

An ideal biological warfare agent would be easily disseminated in the open air by using off-the-shelf devices such as industrial sprayers or other types of aerosol-producing devices. These could be mounted on an airplane, boat, car, or other moving vehicle, or even placed in a stationary position. An alternative method would be to disseminate the agent in an enclosed space (eg, a building), where it could more efficiently infect or intoxicate humans living or working in the area. In addition to having the proper particle size, an ideal agent might also be dried (by freeze-drying or spray-drying), which would make it easier to disseminate widely and over longer distances. As noted above, some toxins, although inherently very toxic, have low-enough lethality that massive (ton) amounts would be required to cover any significant area. Delivering such amounts to a battlefield might be logistically very difficult, if not impossible. Although logistical difficulties mitigate against using toxins of low lethality as open-air weapons, they could be used on a smaller scale (eg, in an enclosed space such as a building, or as an assassination or terrorist weapon). Such uses may become more likely considering the kinds of limited conflicts and terrorist scenarios that we face in the post–Cold War world. Medical personnel must be alert to the possibility of such “surprise” attacks, which could occur even within our own borders.

## Stability After Production

Once a biological warfare agent is produced in quantity by an adversary, it must be fairly stable—either in bulk storage or once put into a weapon or a delivery system. It must, therefore, retain its viability and virulence or toxicity during production, storage, transportation, and delivery. Agents that have a very short shelf life or those that are subject to rapid degradation in the environment once released would, by definition, be poor biological weapons. On the other hand, those with long shelf lives, or those that are very slowly degraded by environmental influences such as temperature extremes, dryness, or ultraviolet radiation, would be more useful as weapons, assuming other requirements are met. Anthrax spores are one example of an ideal agent from this standpoint, as they are both very hardy in the environment and stable in storage. Studies[1] on Gruinard Island off the northwest coast of Scotland, where the British conducted field trials with anthrax in the early 1940s, showed that in the right conditions anthrax spores can remain viable for 50 years or more. However, even anthrax spores are susceptible to breakdown by high ultraviolet (bright sunlight) exposure.

## Susceptibility and Nonsusceptibility

The ideal biological warfare agent would be one to which the target force is known to be susceptible (ie, not immunized against) but to which the aggressor force possesses high levels of immunity, usually via vaccination. When used as aerosols, biological warfare agents are only as predictable as the weather: a shift in wind direction could blow the agent cloud back over the aggressor’s position, which could be catastrophic if his forces were unprotected against the agent. It is assumed, therefore, that an aggressor will attempt to immunize his forces against agents that he is planning to use tactically, although this is not necessarily the case for all countries with offensive biowarfare programs. It is also desirable that an infectious biological warfare agent not produce an uncontrollable epidemic that might ultimately infect friendly forces due to person-to-person spread of disease. With toxins, obviously, this is not a consideration.

## METHODS OF DELIVERY

Biological agents may be delivered in either wet or dry form. Dry powders composed of very small particles tend to have better dissemination characteristics, and have advantages in storage. Dried agents require an increased level of technological sophistication to produce, although freeze drying or spray drying technology has been available in industry for a number of years.

Biowarfare agents might be released by an aggressor against our forces or against civilian populations by means of sprays, explosive devices, and contamination of food and water. Most commonly, delivery methods use aerosolized agent.

The agent can be dispersed by attaching a spray device to a moving conveyance. An industrial insecticide sprayer designed to be mounted on an aircraft is an example. A line of release would then occur while the sprayer is operating. This is known as a *line source*, and is sprayed perpendicular to the direction of the wind, upwind of the intended target area. Up to a certain range, anyone downwind of such a line source would theoretically be at risk. The range that the infectious or toxic agent would reach depends on a number of factors, including wind speed and direction, atmospheric stability, and the presence of inversion conditions; and on characteristics of the agent itself (eg, stability to desiccation or ultraviolet light). Studies[2] using computer models have shown that clouds of hardy organisms such as anthrax spores can be infectious more than 200 km from the source of the aerosol.

A second type of aerosol source is a *point source*, which is a stationary device for aerosolization of the agent, such as a stationary sprayer. A modified point source would be a group of spray devices, such as specially designed bomblets dispersed in a pattern on the ground by a missile or artillery shell designed to release such bomblets. Many such devices have been designed; an example is the Flettner rotor (Figure 20-2). Several types of spherical bomblets have also been widely tested, and most biological bomblets are spherical (Figure 20-3). Bomblets may be designed to disseminate on impact or at a predetermined altitude above the ground. They may be released from missiles or aircraft, and may have special designs to improve their aerodynamics or pattern in the target area.[3]

Other types of delivery systems for biological agents have been designed by various countries. These include bombs or bomblets that release the agent by exploding (generally very inefficient delivery systems), land and sea mines, pipe bombs, and many other special devices.[3] *Clandestine* means of delivering biological warfare agents are potentially available to terrorists or special forces units; these include devices that penetrate and carry the agent into the body via the percutaneous route, such as pellets or flechettes, or means to contaminate food or water supplies so that the agent would be ingested.

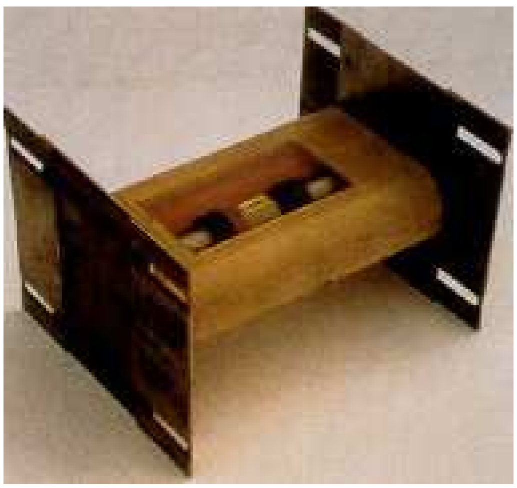


**Fig. 20-2.** The Flettner rotor, a 7-in.-long winged biological bomblet design, was a test design that was never standardized (ie, selected to be mass produced). It could carry either liquid or dry biological agents. This type of bomblet was designed to be released from cluster bombs, dispensers, or missile warheads, and spray out agent on impact. The fins were designed to extend by centrifugal force in flight to stabilize the bomblet's flight path to the target area. Reprinted from van Keuren RT. *Chemical and Biological Warfare, An Investigative Guide*. Washington, DC: Office of Enforcement, Strategic Investigations Division, US Customs Service; 1990: 85.

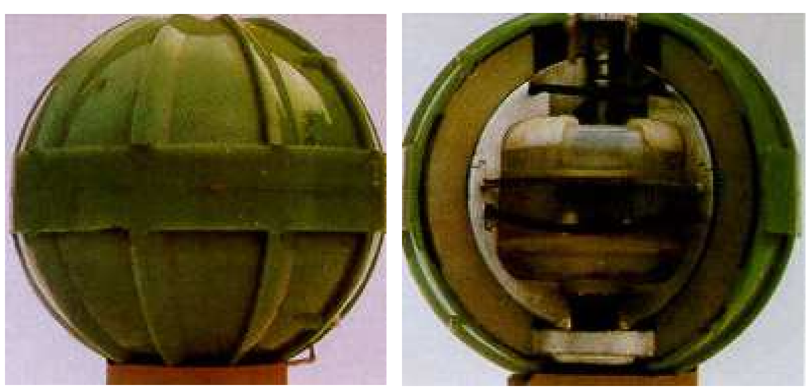
a  b

**Fig. 20-3.** The E120 biological bomblet was one of a number of spherical biological bomblets that were developed before the United

States discontinued its offensive program in the 1970s. **(a)** The vaned outer shell of this spherical bomblet was designed to provide rotation during flight. On impact, the outer shell would shatter; the bomblet was asymmetrically weighted so that agent would then be sprayed from the top of the bomblet. **(b)** Cutaway view of the E120 biological bomblet. Reprinted from van Keuren RT. *Chemical and Biological Warfare, An Investigative Guide*. Washington, DC: Office of Enforcement, Strategic Investigations Division, US Customs Service; 1990: 79.

## ADVANTAGES AND DISADVANTAGES OF USING BIOLOGICAL WEAPONS

Biological weapons offer many potential advantages to an aggressor who chooses to use them. However, some of the advantages may be counter-balanced by several key disadvantages, most of which also apply to the aggressor force (Exhibit 20-2). In addition, the threat of impending attack with biological warfare agents can create psychological effects out of proportion to the military threat.

### Advantages

An attack using biological weapons may be more sinister than an attack using conventional, chemical, or nuclear weapons, where effects are more immediate and obvious. By the time the first casualty is recognized, the agent may have already been ingested, inhaled, or absorbed by many others and more casualties may be inevitable despite medical countermeasures. Minute particles can silently pass through the air supply systems of ships, vehicles, command headquarters, sleeping quarters, and even hospitals.

**EXHIBIT 20-2**
**ADVANTAGES AND DISADVANTAGES OF BIOLOGICAL WEAPONS**

**Advantages**

- The potential deadly or incapacitating effects on a susceptible population
- The self-replicating capacity of some biological agents to continue proliferating in the affected individual and, potentially, in the local population and surroundings
- The relatively low cost of producing many biological weapons
- The insidious symptoms that can mimic endemic diseases
- The difficulty of immediately detecting the use of a biological agent, owing to the current limitations in fielding a multiagent sensor system on the battlefield, as well as to the prolonged incubation period preceding onset of illness (or the slow onset of symptoms) with some biological agents
- The sparing of property and physical surroundings (compared with conventional or nuclear weapons)

**Disadvantages**

- The danger that biological agents can also affect the health of the aggressor forces
- The dependence on prevailing winds and other weather conditions on effective dispersion
- The effects of temperature, sunlight, and desiccation on the survivability of some infectious organisms
- The environmental persistence of some agents, such as spore-forming anthrax bacteria, which can make an area uninhabitable for long periods
- The possibility that secondary aerosols of the agent will be generated as the aggressor moves through an area already attacked
- The unpredictability of morbidity secondary to a biological attack, since casualties (including civilians) will be related to the quantity and the manner of exposure
- The relatively long incubation period for many agents, a factor that may limit their tactical usefulness
- The public's aversion to the use of biological warfare agents

Biological weapons are also unique in their ability to inflict large numbers of casualties over a wide area—with minimal logistical requirements and by means that can be virtually untraceable.[4] In 1970, the World Health Organization estimated[5] that if 50 kg of anthrax spores were dispersed upwind of a population center of 500,000 people in optimal weather conditions, almost half of the population of that area would be either disabled or killed in such an attack (Table 20-1). This highlights the mass casualty–producing potential of these agents.

The ease and low cost of producing an agent, the difficulty in detecting its presence and protecting (and treating) its intended victims, and the potential to selectively target humans, animals, or plants make defense against this class of weapon particularly difficult.[4] An enemy may also be able to deny the use of such a weapon after casualties occur, claiming that a natural outbreak of an endemic disease with similar symptoms is to blame for the occurrence of disease in friendly forces.

Another advantage of biological warfare to an enemy is that defensive programs always tend to lag behind the current offensive threat. This is due to three major factors[6]:

1. Defensive efforts are not initiated until the threat is evident.

2. Defensive systems generally require longer development times in comparison to offensive systems.

3. Medical defenses may be even more problematic and take even longer to field due to important regulatory requirements that impose strict guidelines on the development of vaccines and prophylactic drugs for use in human beings.

**Table 20-1 is not shown due to copyright restrictions, please refer to the textbook.**

The United States remains vulnerable to the strategic, tactical, and terrorist use of biological weapons. There may a tendency on the parts of some potential adversaries of this country to overcome their conventional military disadvantages by choosing weapons of mass destruction that can be produced easily and cheaply, and with technology already available to them. The cost advantage of biological weapons was clearly illustrated by a 1969 United Nations report[4] that estimated the cost of operations against civilian populations at $1.00 US/km$^2$ for biological weapons, versus $600.00/km$^2$ for chemical, $800.00/km$^2$ for nuclear, and $2,000.00/km$^2$ for conventional armaments.

Thus, from several standpoints, including cost, availability, relative technological feasibility, ease of dissemination, difficulty of detection, deniability, and ability to cause mass casualties, biological weapons may be very attractive as weapons of mass destruction for adversaries of the United States or its allies.

**Disadvantages**

Many of the disadvantages to using biological warfare agents—both to the target population and to the aggressor forces—have been presented in testimony to the U.S. Congress and in public documents,[7–9] but it should be noted that biological warfare organisms or toxins have never been used against U.S. forces. Therefore, we have no practical experience with their use.

A major disadvantage to the use of biological weapons is that, since they are widely viewed as weapons of mass destruction and out of the ordinary, their use may bring about the escalation of a military conflict (ie, in the type of retaliatory attack). Since there are no biological weapons in the current arsenal of the United States, and since the effect of chemical weapons is so much more limited in scale and area covered, we can only speculate on the response of the United States if our military forces or civilian populations were attacked with biological weapons. Such concerns may be one reason why Iraq elected not to use chemical or biological weapons in the Persian Gulf War.

Certain types of biological weapons systems may be more disadvantageous than others to aggressor forces. For example, bomblets delivered on a target leave a definable biological warfare signature, and up to 5% of the agent may remain as residue after the contents have been expended. Therefore, the remaining agent could be identified and used to prove culpability. The residua could also be used to tailor medical treatment or postexposure prophylaxis, thus mitigating the intended results of the attack. [3]

### Psychological Factors

By virtue of their invisibility and undetectability, biological agents may be more psychologically disruptive than conventional weapons, especially to an unprepared military unit. The prospect of dying from an incurable, potentially painful, and highly communicable disease can create a panic among unprotected soldiers trained to fight against conventional weapons only. Most military organizations have little experience in dealing with casualties of biological warfare, and facing an unknown threat can give rise to considerable anxiety and fear. Even the prospect of facing such a threat can create a great deal of concern. These fears were seen in numerous instances in Saudi Arabia during the Persian Gulf War.

Concerns over biocontamination may affect or even halt operations at key bases or facilities. Medical personnel may be even more susceptible to concerns over biowarfare, as they are more likely to understand the effects that would follow enemy use of such weapons. This was seen in the Gulf War, as individual personnel in medical units had a better appreciation for the potential vulnerability that a lack of adequate stocks of vaccine might create.

It is not only the threat of use of biological warfare agents that creates psychological stress, however. The tremendous difficulties involved with continuing unit operations in a biological or chemical environment may have a profound psychological impact. Medical care in such an environment may require the use of individual protection of varying degrees, group or collective protection, decontamination, transfer of contaminated patients or medical supplies through a particular corridor (eg, from an air force base to an army hospital), and contained operations for extended periods.[10] This increases the difficulty of what is already hard enough: providing modern medical care in an austere field environment. The stress of trying to do so may be psychologically overwhelming, particularly if medical units have not trained to operate in nuclear, biological, and chemical (NBC) environments. All military units, including medical units, must be prepared to perform their mission-essential tasks under NBC conditions.[11] The only way to assure that our medical units are ready to do so is to train under realistic conditions. Medical planners must ensure that such training occurs regularly and often.

## STRATEGIC AND TACTICAL CONCERNS

Knowledge and understanding of enemy strategy, tactics, and doctrine are essential parts of waging a successful military campaign. This understanding includes an appreciation of whether the enemy possesses biological weapons and in what quantity, what might compel him to use them, and in what manner he would employ them. Biological weapons have the potential of inflicting heavy casualties in selected areas, contaminating personnel and equipment, causing disruption of troop movement and maneuvers, impacting on resources in forward and rear areas, and restricting or denying the use of terrain by friendly and enemy forces.

Biological weapons, when compared with nuclear weapons, are less likely to cause wide-spread physical devastation. Likely scenarios of use include large-scale attacks against fixed rear areas and forces, such as supply points, ammunition dumps, airbases, command and control assets, and fixed medical facilities; or application on a more-limited scale to cause disruption rather than annihilation. As a force is demoralized and reduced by disease and strange illnesses, attrition may become a more significant factor. It is less likely that an enemy would attempt to use biological warfare weapons against tactical maneuver units, owing to those units' high mobility and the fact that effects on such units may not occur quickly enough to be decisive in the enemy's favor.

A proper defense against biological weapons thus requires *(a)* an understanding of the enemy and his likely objectives for a biological attack, and *(b)* the adoption of effective personal protective measures to minimize their impact. Biological defenses and future detection efforts should be emphasized in areas of the battlefield where an enemy attack is most likely. However, since an adversary may attempt to use biological weapons when and where such an attack is least expected, all efforts should be made to prepare our forces in depth for the possibility of a biological attack. This preparation should include the continued development of better vaccines and prophylactic drugs to protect U.S. military forces deployed to areas where intelligence indicates that an attack with biological agents is likely.

Biological warfare agents, by themselves, are not ideal tactical weapons, owing to their unpredictability and delayed effects (long incubation times). They are also viewed as inhumane by many, and their "first use" would generate significant world criticism. Their tactical importance may increase, however, as more is learned about the predictability of damage from specific biological agents. But the U.S. military must be prepared to defend against biological attack at all levels of conflict. Biological warfare agents in combination with other weapons systems must also be anticipated. With the development of new missile delivery systems, even intercontinental delivery of biological agents is possible, and the use of low-flying, long-range cruise missiles or remotely piloted drones may be the best way to generate a dense cloud of biological warfare agents close to the ground. It has been estimated that under suitable conditions, a cruise missile could deliver anthrax spores over an area of the same magnitude as the lethal fallout from a ground-burst nuclear warhead.[3] However, much more subtle delivery vehicles (such as an agricultural sprayer mounted on a truck, boat, or other, more conventional platform) could be used to deliver biological agents anywhere in the world.

Simply to maintain a defensive posture against attack is not adequate, however. The U.S. military must be able to sustain an offensive campaign in a biologically contaminated environment. To do otherwise is to invite use of such weapons by the enemy. The impact of infectious diseases on military units has been well documented in past wars, but the potential fielding of highly lethal agents by adversaries for use as biological warfare weapons makes personal protective measures and command-driven discipline even more important for today's army.

While the more accurate conventional weapons systems that are currently fielded by some military forces produce less collateral damage, an aggressor using biological or chemical weapons may use multiple weapons or dissemination devices to cover a large area. Biological weapons could be effective if the enemy's goal was to preserve logistical materiel; this presupposes the enemy use of captured friendly weapons and infrastructure, as opposed to mass physical destruction, thereby making biological weapons more attractive to an enemy than nuclear weapons to accomplish this purpose.[12,13]

## UNCONVENTIONAL WARFARE AND TERRORISM

The U.S. Department of State estimates that more than 6,000 terrorist incidents have occurred in the world since 1980, with more than 4,000 people killed and 11,000 wounded.[14] Many terrorist groups have been supported by countries with substantial research, development, and weapons capabilities. Countries like Iran and Iraq, which are known to have links to terrorist groups, have long been suspected of having offensive biological warfare programs. Assassinations with biological agents such as ricin have been carried out effectively (see Chapter 32, Ricin Toxin).

Biological weapons may, in fact, be much more effective if used against unsuspecting, unprotected, and nonimmune civilian populations than against a fast-moving military organization. This was certainly true when the Japanese attempted to use biological weapons against Chinese and Soviet troops in World War II. The objectives of a terrorist group may not be typical military objectives; therefore, biological weapons may be better suited to their purposes.[15]

Many factors may make biological agents particularly attractive to terrorists. The availability of less-sophisticated biological weaponry has been mentioned earlier in this chapter. Biological weapons can be employed effectively as a means of terrorism or sabotage, especially in rear-echelon areas, port or staging sites, and industrial and storage areas. Biological weapons could also be used against civilian populations, creating panic.

The contamination of logistical supplies is a well-recognized possibility, and security in all areas of the battlefield is of great importance when dealing with an enemy with such capabilities. The stealth with which these weapons may be employed is a factor, especially if the terrorist wishes to escape detection before the results of the attack are obvious.

The use of biological warfare in rear areas close to local civilian populations also might create large numbers of civilian casualties. How would military medical personnel respond to civilians seeking care at medical treatment facilities? And how can civilian casualties be factored into medical planning? These are only two of many unanswered questions relating to development of realistic medical doctrine for management of biological casualties.

Terrorist or criminal use of biological agents may also not be limited to the battlefield or a theater of operations. As the World Trade Center bombing in New York illustrated in January 1993, terrorist attacks within the borders of the United States are certainly possible. Knowledge of microbiology and its potential applications is widespread, and development of a crude biological weapon does not require extensive expertise.

Several attempts at biological sabotage have occurred within the United States. Even an attack that turns out to be a hoax may have significant public impact: the 1992 case of a Tyson's Corner, Virginia, man, who sprayed his neighbors with a fluid he claimed contained anthrax is illustrative. This incident caused local hazardous material teams to be deployed, the house involved to be quarantined, and numerous individuals to go to local hospitals for care.[16]

An incident on a larger scale could create a panic and cause hundreds or even thousands of people to seek medical care. The potential impact on health care facilities in the area of an attack or even a threatened attack is tremendous. Emergency departments may be "overrun" with patients, open hospital beds may become scarce, intensive care units may be filled, and antibiotic stocks may be depleted.

Possible scenarios for criminal or terrorist attacks with biological agents include four basic types[15]; the examples demonstrate that terrorist acts have already occurred using chemical agents:

1. product tampering (eg, the Tylenol tampering cases of the 1980s);
2. attacks on specific ethnic population groups within a country, who are perceived to be in opposition to terrorist goals;
3. sabotage of specific food groups or industries, such as contamination of an imported food product with a toxin, pathogenic bacteria, or poison (eg, the lacing with cyanide of Chilean grapes in March 1989); and
4. attacks directed at one of a country's institutions, agencies, or departments such as the military, a stock market, or a major communications center.

Because of the variety of possible scenarios and the likely similarity of the medical effects of such attacks to endemic disease outbreaks, medical personnel will have to be extremely alert to differentiate the initial cases resulting from biological warfare terrorism from naturally occurring disease.

Biological terrorism could range from the use of sophisticated biological warfare weapons such as dried anthrax spores or botulinum toxins to unsophisticated agents such as *Salmonella* or other common bacteria. The agent used and the mechanism of delivery may depend to a great extent on whether the terrorists are sponsored by a government. Although cutting-edge biotechnology research requires an infrastructure of sophisticated laboratories, and production of sophisticated biological weapons may require specialized equipment, some effective biological pathogens or toxins may be produced or harvested using relatively primitive techniques.[17] A state-sponsored terrorist group is, however, much more likely to have the wherewithal to produce casualties on a large scale; the unsupported single operative may still have a devastating impact, but on a much smaller scale.

Consider, for example, the difference between the hypothetical potential casualties produced by a state-sponsored terrorist spraying dried anthrax from a crop duster airplane northwest of Washington, D.C., versus an unsponsored, disgruntled employee sprinkling a species of *Salmonella* in broth culture on the salad bar in the company cafeteria. The difference in potential medical impact is obvious. Countries suspected to have biological programs that may support terrorist activities include Iran, Iraq, Libya, and North Korea.[17] The operative question may not be *whether* biological agents will be used as terrorist weapons against the United States, but rather *when*.

## DETECTING BIOLOGICAL WARFARE AGENTS

A satisfactory battlefield biological defense requires a sensitive environmental monitoring system to be employed, one that can detect the presence of toxic or infectious biological materials in the environment in a manner similar to chemical agent detectors.[12] A distinction must be made here between detection of biological agents in the environment (detection, monitoring, or standoff detection) and medical diagnostics (detection of biological agents, components of biological agents, or antibodies to biological agents in tissue samples such as blood or other body fluids). Environmental biological detectors must be reliable and sensitive to be useful, and also must be able to determine when a previously contaminated area is safe. Medical diagnostics depend on fieldable laboratory testing.

### Environmental Detection and Monitoring

Once a biowarfare agent has been dispersed, detection of the aerosol prior to its arrival over the target, in time for personnel to don their protective equipment, is the best way to minimize or prevent casualties. When properly fitted and worn, currently issued chemical protective equipment is also effective in protecting personnel from biological agents (see Chapter 16, Chemical Defense Equipment). However, there are no currently fielded means of detecting biological agents in the environment in real time, and until reliable detectors are fielded, the first indication of a biological attack against unprotected soldiers will likely be one or more ill soldiers. The situation may be as simple as a few patients with respiratory illness, or as complex as a mass casualty situation.

Evolving detector systems are an area of intense interest with the highest priority within the research and development community. A Biological Integrated Detection System (BIDS) is planned for fielding within the next several years (see Figure 16-32 in Chapter 16, Chemical Defense Equipment). This system will be vehicle mounted and will test environmental air samples, by concentrating appropriate aerosol particle sizes in the air samples, then subjecting the sample to analytical- and antibody-based detection for selected agents. Also planned for future use is the Tactical Biological Standoff Detection System, which, when fielded, will provide for the first time a biological standoff detection capability to both provide early warning and activate the NBC Warning and Reporting System. The Tactical Biological Standoff Detection System will employ ultraviolet laser and laser-induced fluorescence to detect biological aerosol clouds at a standoff distance of up to 5 km. This system will be available for fixed-site applications or inserted into various transport platforms such as fixed-wing or rotary aircraft, tactical vehicles, or unmanned aerial vehicles. The other standoff detection system now in the research and development phase is the Strategic Biological Stand-off Detection System, which will provide a long range/large area aerosol detection, tracking, and mapping capability. This system has the potential to detect aerosol clouds out to ranges of 100 km. The information will be used to provide early warning, enhance contamination avoidance efforts, and cue tactical-level (ie, unit-level) detection assets. The strategic standoff detection system is envisioned for theater use in existing fixed- and rotary-wing aircraft.[18]

The principal difficulty in detecting biological agent aerosols stems from differentiating the artificially generated biological warfare cloud from the background of organic matter normally present in the atmosphere. Therefore, medical protection (vaccines and other prophylactic measures), intelligence, medical surveillance and medical diagnostics, and physical protection during times of high threat must be relied on as primary defenses in the absence of currently fielded environmental biological detectors.[18]

**Epidemiological Surveillance**

An epidemiological surveillance system that closely monitors unusual illnesses or outbreaks of disease is also extremely important. It is difficult for command medical advisors to know if a disease outbreak is consistent with a biowarfare attack unless background rates of disease for an area of operations are known. A theaterwide epidemiological surveillance program is therefore a necessity for informed advice to the theater commander. Surveillance programs must be specifically tailored to both the mission and the geographical area where the mission is based, and they must be focused toward specific, diagnosable disease entities. Generic surveillance systems that lump disease and injury into broad categories such as “respiratory” or “dermatological” are nearly useless as epidemiological indicators of a biological warfare attack. Early and rapid analysis of specific epidemiological surveillance data may be the first clue, however, that such an attack has occurred.

In addition to specific clinical clues that suggest illness from biological threat agents (eg, a widened mediastinum in the terminal phases of inhalational anthrax), certain epidemiological indicators may suggest that a biological warfare attack has occurred (Exhibit 20-3).[19] All medical surveillance teams and healthcare providers need to keep these indications in mind; findings such as these should heighten suspicion that a biological attack has occurred and provoke specific and vigorous diagnostic steps aimed at isolating the cause of the outbreak.

**Medical Diagnostics**

Medical diagnostics are also extremely important. A field medical laboratory capable of identifying live agents or toxins quickly and accurately in medical samples is an absolute necessity if the use of biological weapons by the enemy is a possibility. Viral agents and toxins present the most difficult diagnostic problems for current diagnostic tests, which are based on polymerase chain reaction (PCR), radioimmunoassays, or enzyme-linked immunosorbent assays (ELISAs). Laboratory capabilities must be tailored carefully to intelligence information on enemy biological warfare capabilities and also to information on specific endemic diseases that are likely to occur in the theater of operations.[18]

**EXHIBIT 20-3**
**INDICATIONS OF POSSIBLE BIOWARFARE ATTACK**

- A disease entity that is unusual or that does not occur naturally in a given geographic area, or combinations of unusual disease entities in the same patient populations
- Multiple disease entities in the same patients, indicating that mixed agents have been used in the attack
- Large numbers of both military and civilian casualties when such populations inhabit the same area
- Data suggesting a massive point-source outbreak
- Apparent aerosol route of infection
- High morbidity and mortality relative to the number of personnel at risk
- Illness limited to fairly localized or circumscribed geographical areas
- Low attack rates in personnel who work in areas with filtered air supplies or closed ventilation systems
- Sentinel dead animals of multiple species
- Absence of a competent natural vector in the area of outbreak (for a biological agent that is vector-borne in nature)

Source: Wiener SL, Barrett J. Biological warfare defense. In: *Trauma Management for Civilian and Military Physicians*. Philadelphia, Pa: WB Saunders; 1986: 9.

Both ELISA-based testing and specific testing for minute amounts of specific genetic material of biological agents in medical samples using PCR techniques are feasible for deployment and use in a field setting.[20] Both epidemiological surveillance and field laboratory capabilities are receiving a great deal of attention currently as the U.S. Army Medical Department prepares for the next conflict in which both endemic disease and biological warfare are legitimate threats.

## SUMMARY

Biological warfare could be used against the United States in a theater of operations or against our civilian populations in any number of realistic scenarios. The medical consequences of such use are potentially catastrophic unless measures are taken to minimize the potential impact of biological warfare agents on our people. Proper planning for terrorist as well as military scenarios, better and more realistic training under NBC conditions, adequate environmental detection and monitoring, improved vaccines and prophylactic drugs for our military, and sensitive and specific medical diagnostics are all pathways toward defending against the possible nightmare of biological attack.

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