Biological Warfare and Its Defense

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SINCE any enemy nation might be expected to use all the weapons in its arsenal, it would follow that it would give serious consideration to biological warfare. Because of this possibility it is incumbent upon each of us to become fully acquainted with the nature of biological warfare.

What BW Is

By way of definition, biological warfare is the intentional use of living micro-organisms or their toxic products for the purpose of destroying or reducing the military effectiveness of man. Man may also be injured secondarily by damage to his food crops or domestic animals. The military objective, of course, is to reduce the will or capability to wage war.

It has sometimes been said that BW is public health practice and procedure in reverse. This is an erroneous conception. BW is the deliberate use of natural disease agents whose inherent potential has been exploited by scientific research and development resulting in the production of BW weapons systems.

Military campaigns and troop concentrations have always provided a fertile field for naturally occurring epidemic disease. Infectious disease has often been the critical factor in the outcome of a military campaign.

Bubonic plague was said to have stopped the Crusaders at the very gates of Jerusalem. Dysentery probably caused more casualties in Napoleon's Grand Army than enemy firearms. Typhoid fever and dysentery played no favorites among the opposing forces in the Civil War, the Boer War, and the Spanish-American War. The new science of bacteriology was in its infancy around 1900. Even during World War I, infectious disease was a controlling factor in some campaigns. It is quite clear that typhus fever prevented the Germans from carrying through their Balkan campaign.

In spite of all our modern sanitation and preventive medicine, infectious disease contributed a large share to the cost and difficulty in World War II. Malaria ranked high as an enemy, both in the Mediterranean and in the Southwest Pacific, and scrub typhus caused some 7,000 casualties in the latter area. And finally, it seems almost yesterday that enteric infections, Japanese B encephalitis, and hemorrhagic fever were bedeviling us in the Korean conflict.

In the past, a number of crude, unscientific, and purely local efforts were made to utilize infectious disease for military purposes. Alexander attempted such exploitation by catapulting the bodies of dead men and animals over the walls of besieged cities. It is reported that smallpox was started successfully among the American Indians during the French and Indian War by distributing blankets contaminated with purulent smallpox material. In World War I the Germans infected with glanders horses that were consigned from this country to the Roumanian cavalry. During World War II a number of units of the German Occupation Forces, particularly in Eastern Europe, were said to have been the target of local sabotage efforts with bacteriological agents.

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All of these efforts were, of course, small, local, makeshift, and unorganized with respect to centralized control and direction. It was not until early in World War II that an officially planned program was devoted to research and development in biological warfare. This has continued to the present time as a recognized activity of the Department of Defense. Responsibility for carrying out a program was delegated to the Department of the Army which, in turn, assigned the operational responsibility to the Army Chemical Corps. The major portion of the research and development is conducted at Fort Detrick in Frederick, Md. Close liaison is maintained with other Federal agencies having defensive responsibilities, including the Federal Civil Defense Administration, the Public Health Service, the Food and Drug Administration, and the Department of Agriculture. That a program of research and development continues in permanent facilities constructed for the purpose can be considered as recognition of the potential of the weapon and thus of the defensive problems which we must be prepared to meet.

Effective Agents

Biological warfare is considered to be primarily a strategic weapon which makes it a particular defensive problem for civilian population centers. The major reason for this is that it has no quick-kill effect. The incubation period of infectious disease plus a variable period of illness even before a lethal effect make this weapon unsuitable for hand-to-hand encounter. A man can be an effective fighting machine throughout the incubation period of most infectious diseases. Hence, an enemy would probably consider this weapon as primarily suited for attack on static population centers such as large cities, and thus our principal concern is with civil defense. There is little point at the moment in considering how it may be used against troops.

An important operational procedure in BW for an enemy would be to create an aerosol or cloud of agent over the target area. This fundamental concept has stimulated much basic research concerning the behavior of biologic particulates, the pathogenesis of respiratory infections, the medical management of such diseases, and defense against their occurrence.

The importance of particle size in such aerosols has been recognized. The natural anatomical and physiological defensive features of the upper respiratory tract, such as the turbinates of the nose and the cilia of the trachea and larger bronchi, are capable of impinging out the larger particles to which we are ordinarily exposed in our daily existence. Very small particles, however, in a size range of 1 to 4 microns are capable of passing these impinging barriers and entering the alveolar bed of the lungs. This area is highly susceptible to infection. The entrance and retention of infectious particles in the alveoli amounts almost to an intratissue inoculation.

In considering BW defense, it is well to know that there are a number of critical micrometeorologic parameters which must be met for an aerosol to exhibit optimum effect. Generally, bright sunlight is rapidly destructive to living micro-organisms suspended in air. There are optimal humidity requirements for various airborne agents. Neutral or inversion meteorologic conditions are necessary in order for a cloud to travel along the surface. It will rise during lapsed conditions. There are, of course, certain times during the 24-hour daily cycle when most of these conditions will be met. This is important in gas warfare also. Moreover, the importance of these meteorologic conditions has long been recognized in connection with certain natural phenomena such as the occurrence and persistence of smog over an area.

Certain other properties of small particles, in addition to those already mentioned in connection with penetration of the respiratory tract, are noteworthy in defense considerations. The smaller the particle, the farther it will travel downwind before settling. An aerosol of such small particles diffuses through structures in much the same manner as a gas, a property of considerable importance in connection with certain defensive considerations.

A number of unique medical problems might be created when man is exposed to an infectious agent through the respiratory route rather than through the natural portal of entry. Some agents have been shown to be much more toxic or infectious to experimental animals exposed to aerosols of optimum particle size than by the natural portal. Botulinal toxin, for example, is several thousandfold more toxic by the respiratory route than when given by mouth. In some instances, a different clinical disease picture may result from this route of exposure, making diagnosis difficult. In tularemia produced by aerosol exposure, one would not expect to find the classical ulcer of "rabbit fever" on a finger.

There are a number of agents that an enemy might select from the several classes of microorganisms (bacteria, viruses, rickettsiae, fungi, or toxic products of certain organisms). There are, however, certain general characteristics that should be met in making a selection.

An enemy would obviously choose an agent that is believed to be highly infectious. Agents that are known to cause frequent infections among laboratory workers, such as those causing Q fever, tularemia, brucellosis, glanders, coccidioidomycosis, belong in this category.

An agent would likely be selected which would possess sufficient viability and virulence stability to meet realistic minimal logistic requirements. It is, obviously, a proper goal of research to improve on this property. In this connection an agent should be capable of being disseminated without excessive destruction. Moreover, it should not be so fastidious in its growth requirements as to make production on a militarily significant scale improbable.

An aggressor would seek minimal, naturally acquired or artifically induced, immunity in a target population. A solid immunity is the one effective circumstance whereby attack by a specific agent can be neutralized. It must be remembered, however, that there are many agents for which there is no solid immunity and a partial, or low-grade, immunity may be broken by an appropriate dose of agent.

There is a broad spectrum of agents from which selection for a specified military purpose might be made. An enemy might choose an acutely debilitating agent, a chronic disease producer, or one causing a high death rate.

It is possible that certain mutational forms may be produced such as drug-resistant strains. Mutants may be developed with changes in biochemical properties that are of importance in identification. All these considerations are of critical importance in considering defense and medical management.

One point needs serious emphasis. The likelihood of creating an entirely new agent of unique virulence, or new disease-producing capability, is extremely remote. Even the remarkable genetic progress made in producing bacterial transformation in recent years does not warrant deviation from this opinion at the present time.

Certain general considerations in connection with BW agents merit some discussion.

Biological agents are, of course, highly host-specific. They do not destroy physical structures as is true of high explosives. This may be of overriding importance in considering military objectives.

One must be unremitting in emphasizing that there is no secrecy concerning the agents which might be included in an overall BW arsenal. Only certain agents will meet the general and specific BW requirements. Both we and any potential enemy know them. This is not like inventing or rather synthesizing a new chemical poison. One frequently hears it said, "If we only knew what agents our potential enemies were working on, we would know what to defend ourselves against." This platitudinous statement is parroted ad nauseam. This is the kind of statement that is made by an ostrich before burying his head in the sand. A more appropriate conjecture would be to ask ourselves, "What are we doing about it? Are we doing enough?"

The question of epidemic disease also merits some discussion. Actually, only a limited effort has been devoted to this problem in the research and development program. Some of the bitterest critics of BW have assumed that the only potential would be in the establishment of epidemics. They then point out that with mankind's present lack of knowledge of the factors concerned in the rise and fall of epidemics, it is unlikely that a planned episode could be initiated. They argue further, and somewhat contradictorily, that our knowledge and resources in preventive medicine would make it possible to control such an outbreak of disease. We agree with this in general, and this is why this approach to BW defense has not been given major attention in the program. One can charitably hope that such critics never have to breathe air laden with an infectious agent!

Our main concern is what an enemy may accomplish in the initial attack on a target. This, of course, does not eliminate from consideration for this purpose agents that are associated naturally with epidemic disease. A hypothetical example will illustrate this point. Let us assume that it would be possible for an enemy to create an aerosol of the causative agent of epidemic typhus (*Rickettsia prowazekii*) over City A and that a large number of cases of typhus fever resulted therefrom. No epidemic was initiated nor was one expected because the population in City A was not lousy. Lousiness is a prerequisite for epidemic typhus. In this case, then, the military objective was accomplished with an epidemic agent solely through the results accomplished by the initial attack. This was done with full knowledge that there would be no epidemic. On the other hand, a similar attack might have been made on City B whose population was known to be lousy. One might expect some spread of the disease in this case, resulting in increased effectiveness of the attack.

The great inherent potency of BW agents is due to their capacity to multiply when successfully implanted in a susceptible host.

Biological agents are, of course, suitable for delivery through enemy sabotage, which imposes many problems in defense. One can let one's imagination run wild in this regard. One might mention a few obvious, but nevertheless important, areas. The air-conditioning and ventilating systems of large buildings are obvious targets. America is rapidly becoming a nation that uses processed, precooked, and yes, even predigested foods. This is an enormous industry that is subject to sabotage. One must include the preparation of soft drinks and the processing of milk and milk products. Huge industries are involved also in the production of biologic products, drugs, and cosmetics which are liable to this type of attack. These few major areas have been mentioned since sabotage in them would be far reaching in its consequences. Furthermore, all are subject to prophylactic defensive action.

Our major defensive problems, of course, are concerned with the possibility of overt military delivery of biological agents from appropriate disseminating devices. It should be no more difficult to deliver such devices than other weapons. The same delivery vehicles—whether they be airplanes, submarines, or guided missiles—should be usable. If it is possible for an enemy to put an atomic bomb on a city, it should be equally possible to put a biological agent cloud over that city. This points up an enormously important civil defense problem which will be considered in more detail later.

Antifood BW

Another aspect of biological warfare is the possible use of biological agents for the reduction or destruction of agricultural crops and domestic animals, in other words, antifood biological warfare.

The importance of food, particularly during war, needs no emphasis. Actually food production is of major concern to most countries even during peacetime. We are one of the few countries in the unusual position of finding overproduction a major problem.

In all wars, moreover, military efforts have been devoted to the destruction of the enemy's food supply. The grain-laden freighter was as much a prize for a submarine as a ship loaded with tanks.

Biological warfare may find its greatest effectiveness when used for anticrop and antianimal purposes. Contrary to the case in antipersonnel BW, the epiphytotic and epizootic potential of anticrop or antianimal agents would be exploited by an enemy. Antifood biological warfare could play a decisive role in any war that was not decided with pushbutton speed. This country is in a favorable defensive position in anticrop warfare. Our cropping is very diversified and biological agents are, of course, specific for particular crops. Those countries that are generally dependent, for agronomic, climatic, or traditional reasons, on a single crop are the most vulnerable.

It is hoped that this general consideration of biological warfare will serve as a useful framework around which one can build one's defensive thinking and planning. Let us now consider some of the general features of this problem.

Defensive Bank Account

It may seem trite, but nevertheless it is worth while to emphasize, that there is a vast amount of medical knowledge in existence which can be useful. In this sense BW is not completely new. We have had long medical and epidemiological experience with infectious diseases. We have a vast public health effort in being at the Federal, State, and local levels. Our sanitary engineering practices and methods for disease control are at a high level of efficiency. All of these are positive values in our defensive bank account which can be drawn upon in an emergency and would be of great value.

One must not be complacent, however, and be lulled into thinking that BW would be rendered ineffective by these aids. This is not so. These techniques have been developed over the years for dealing with naturally occurring infectious disease. The military exploitation of massive amounts of highly infectious agents through unusual portals of entry creates new problems for which these procedures were not designed and against which no experience has been developed. One might illustrate this point. Adequate means have been developed, for example, for delivering potable water to all inhabitants in a community. We now take this for granted. On the other hand, there is no known public health procedure that will deliver sterile air to all inhabitants of a city. Defense against a massive biological aerosol is a new and critically serious problem.

It is obvious, of course, that medical defensive planning for a community should not be limited to preparation for BW. BW will not cause extensive burns, broken bones, or radiation sickness. All defensive planning should be thoroughly integrated and should be designed to give the maximum practical relief for whatever disaster might befall. For the moment, however, we will consider BW defense only.

One of the most critical problems is detection or early warning. Biological clouds have no characteristics detectable by the senses. They are invisible, odorless, and tasteless, in contrast to certain gas clouds. Even if they possessed an odor, the odor-detecting sniff might result in a sufficient dose to produce an infection.

As is always true, an initial surprise attack will, of course, be the most serious. Later attacks may be suspected by their general characteristics such as possible noise of a disseminating device, recognition of a dud device, and, finally, the realization that something has been delivered that is not a conventional weapon.

The importance of such immediate detection and warning is that it may permit certain defensive actions of a physical nature. The gas mask, for example, affords excellent protection to the respiratory tract if it can be put on in time. Early warning may also permit timely entrance into collective shelters should they exist. It is possible to design quite efficient structures for this purpose.

Some progress is being made in the development of instrumentation for rapidly detecting unusual concentrations of particulate matter in the air.

A closely related problem is rapid specific identification of the particular agent. The ordinary biological methods, employed in the diagnostic laboratory, are far too slow. Identification of viruses is especially tedious. This problem is important in that if the agent can be identified in time, it may permit certain medical prophylactic procedures before the onset of illness. Progress is being made in this field, but much remains to be done. One might suggest at this time that any laboratory conducting research to improve and speed up identification of disease organisms will be making a significant contribution to the defense effort.

Defense Needs

Another defensive activity is decontamination or cleanup after an attack. Much technical knowledge has been developed in this field and is available to defense authorities. One might point out that most of the effort has been devoted to developing procedures for specific and isolated use. One could not hope to decontaminate an entire city. Indeed, this would not be necessary. Sunlight and time are remarkable decontaminants. One may have urgent need, however, for decontaminating specific equipment, structures, or isolated areas.

The most important of all defensive procedures is prophylaxis by active biological immunization. A number of effective immunizing materials are already available for some infectious diseases. On the other hand, there are a number of potential BW agents against which there is no method of immunization. There are several cases where the value of the immunizing material continues to be questionable, at least or where improvement must be sought through research.

One must encourage all research possible that is devoted to the development of new or improvement of old methods of active immunization. All ancillary research dealing with host-parasite relationships will have positive defense value. Moreover, all such research has great peacetime value. It will not be totally consumed in an engine of war.

The administrative problems in connection with the immunization of large populations against a number of agents are enormous. This, too, is an area where research should be fruitful because simplified techniques for rapid, mass immunization are essential. Considerable effort is being devoted to the development of combined or multiple vaccines, an effort that is being rewarded with some success.

There is also the very large field of passive biologic and antibiotic prophylaxis, that is, the use of antimicrobic agents after exposure to the agent but before the onset of illness. This problem merits some detailed discussion.

The use of immune serums, even if effective, would be extremely limited in BW. The production and distribution of the enormous quantities required would be very difficult if not totally unrealistic. On the other hand, the desirability of having some stocks in hand for limited and specialized use should be kept in mind.

More detailed discussion is warranted in connection with the possible prophylactic use of antibiotics and chemotherapeutic drugs. The importance of this has been overplayed in the past. It is essential, therefore, to point out many of the shortcomings of this form of prophylaxis as a guide to future effort.

On several occasions, articles have appeared expounding the thesis that our enormous antibiotic industry has made biological warfare obsolete. This is, of course, ridiculous for a variety of reasons. To permit such reasoning to guide our preparation for defense would be suicidal.

There are many potential BW agents for which there is no known effective antibiotic or drug. Among these may be mentioned *Coccidioides immitis*, *Histoplasma capsulatum*, and, more importantly from a BW standpoint, most of the filtrable viruses.

While we have some antibiotics that exhibit a considerable spectrum of activity, there are others whose greatest value is in use against a specific agent. For prophylactic BW defense after an attack, it would mean, therefore, having the right antibiotic in the right amount at the right place at the right time—a logistic requirement that is almost impossible to meet. Even these considerations may be academic, moreover, when it is realized that the use of drug-resistant strains of agents is not an unlikely possibility.

In some cases it has been shown that giving an antibiotic immediately after exposure merely prolongs the incubation period without preventing infection. Our British colleagues have recently reported that monkeys exposed to lethal respiratory doses of anthrax spores could be treated for several weeks with an antibiotic and would show no signs of infection during that time. When the drug was withdrawn the animals promptly developed fatal anthrax.

One might conclude this discussion of strictly medical prophylaxis by emphasizing that the greatest hope for defense against BW would be the development of effective methods for producing active immunity. Passive prophylaxis with antibiotics and drugs may have limited value. This procedure must not, however, be regarded as a panacea that will render BW obsolete.

There are some additional activities that should be mentioned in connection with BW defense.

Maintaining an adequate epidemiological intelligence service and warning network is of great importance. An unusual occurrence of disease in a particular location may be the first warning of a BW attack. The prompt recognition and reporting of such episodes is essential.

It is important to have available the services of an organized network of laboratories having the qualifications and equipment necessary for the recognition and identification of unusual agents. Such services are needed particularly in the virus field. The personnel in such laboratories should be trained and indoctrinated in those features of BW that may have a special bearing on their responsibilities. This should include training in the use of new detection devices and new procedures for more rapid identification of agents.

There must, of course, be adequate planning for optimum emergency hospital and medical service. Each community must plan the details in this connection.

Our defensive considerations may be concluded with a few words concerning prevention of sabotage. A careful vulnerability study should be made of all sensitive industries and facilities to determine the most likely spots of attack. There should be proper policing and guarding of such spots. Loyal employees should be indoctrinated to the point of being able to augment such guarding. Adequate chlorination of water supplies should be assured. Air-conditioning and ventilating systems of sensitive buildings should be appropriately protected. And, finally, one must not neglect the simple but very effective techniques of heating or boiling food products.

INTERNATIONAL MAIL POUCH

Surinam Sojourn

As a guest of a medical service expedition in Surinam, I was able to study some of the pathologies of Bush Negroes and Amerindians. Four doctors are assigned to serve villages scattered through 43,000 square miles of jungle. At present, only two are well and working. They travel primarily by canoe or small motor craft along rivers and creeks, notwithstanding falls, rapids, logs, alligators, and pythons. There are no roads through the jungles. To follow footpaths and camp overnight is not advisable. The waterways are less strenuous and safer.

—HILDRUS A. POINDEXTER, M.D., *chief public health officer, United States Operations Mission, Surinam.*

Pass the Water

I think we watered an acorn this month. After a year of preliminaries, the provincial government authorized the city of Taipei to hire engineers for the establishment of a sewerage unit. Two weeks ago the mayor decided to activate the unit to design a waterborne sewerage system, initially for the residential half of the city, and to make an official request for the assistance of a WHO design engineer. The start of work was set for the first of the month. Rule-of-thumb cost estimates indicate the project will approximate NT$500,000,000—sufficient to dwarf any other sanitation project now contemplated.

—JAMES P. WARD, M.D., M.P.H., *chief, Public Health Office, United States Operations Mission, China (Taiwan).*

Tribal Vaccination

"May Allah bless you! You young men have risked your lives by crossing these mountain passes to save our lives." A Bakhtiari tribal chief spoke thus to the physician in charge of the Isfahan tribal vaccination program.

The vaccination team first found out what routes the tribesmen in Iran would use on their way to summer pastures and the time they would begin to move. A six-man unit then waited at the mountain pass most of the vast Bakhtiari tribe were to cross. Another unit set up a field clinic at a bridge along the route used by others.

About 200,000 nomads, never before touched by a public health program, were vaccinated against smallpox in Iran within a few weeks.

—ALBERT P. KNIGHT, M.D., *chief, Health Division, United States Operations Mission, Iran.*