Chapter 1

INTRODUCTION TO THE CHEMICAL THREAT

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INTRODUCTION

It has been nearly 90 years since the United States Armed Forces last encountered chemical weapons on the battlefield. Despite this long respite, images of poisonous chemical clouds and descriptions of sudden and horrifying death continue to foment apprehension and terror. The mention of chemical weapons elicits outrage and fear of the unknown. Soldiers confronted with even a nonspecific threat of a chemical environment must bear the inefficiencies of cumbersome and hot protective garments. Medical personnel face an unseen pathogen and the prospect of managing mass chemical casualties they are inexperienced in treating.

Chemical weapons are a classic model of weapons of mass destructive effect that result in substantial contamination of personnel and equipment. Chemical weapons are the original weapons of mass destruction, and they are ideally suited as agents of great psychological effect. Although the law in the United States prohibits using chemical weapons against an adversary, this policy is not shared by all nations or by nonstate entities; therefore, to be effective, military medical personnel must be knowledgeable and trained to deal with a chemical weapon attack.

In a chemical environment, military healthcare providers must be:

- prepared to handle military and civilian casualties resulting from chemical agents;
- cognizant of what constitutes a chemical threat and the military tactics that could be employed against the force because they may be called on to render advice from both individual and public health perspectives;
- familiar with the acute and chronic medical effects of chemical agent exposure in order to plan appropriate medical support; and
- knowledgeable of the diagnostic tools available to identify specific chemical agents to which their patients may have been exposed and aware of the most effective treatments for acute intervention and prevention of long-term sequelae.

The chemical threat may involve overt or clandestine use of single or multiple agents. Some of these may be classic chemical agents developed for military applications. Other agents may be highly toxic industrial compounds that are produced in great quantities and can have comparable effects; increased interest in the training, education, and research of toxic industrial compounds is now emphasized in both the military and civilian populations. Additionally, the advent of more formidable nonstate entities and terrorist organizations interested in the mass lethality and the powerful psychological effects of these agents has resulted in an increased concern for the potential use of chemical weapons.

Chemical warfare agents need not be lethal to be disruptive. The resultant mass casualty scenario, psychological effects, diversion of medical resources, need for decontamination, and impairment of fighting ability are all desirable outcomes for those that might deploy these agents. In a situation where there are few physical indicators of a chemical attack, the medical practitioner may be the first to recognize the effects of chemical exposure. An increased incidence of symptoms consistent with nerve, vesicant, blood, or respiratory agent exposure should raise immediate suspicion of poisoning. Healthcare providers must be familiar with the signs and symptoms of a chemical exposure or the possibility of the combined use of chemical and biological warfare agents in both military and civilian settings.

The offensive use of chemical agents continues to be an attractive alternative to some nations and nonstate entities. One reason for this is that chemical agents can be dispersed over large areas and can penetrate well-defended positions. They can be employed against specific targets (eg, headquarters control centers) with effects that include delayed or immediate incapacitation, disorientation, or death.

The goal of this chapter is to provide an encapsulated historical overview of chemical weapons, discuss the current chemical threat, and guide readers in the organization of this textbook.

A TIMELINE OF CHEMICAL WARFARE AGENTS

Early Chemical Weapons

The modern era of chemical weapons began during World War I with the 1915 introduction of chlorine gas on the battlefield of Ypres, Belgium. Chemical weapons were effective in this theater because of the fixed positions of highly concentrated troop formations. Initial lethal weapons of concern included pulmonary agents such as chlorine and phosgene, for which countermeasures were initially inadequate or nonexistent. As the use of chemical weapons increased, the gas mask was developed as an initial countermeasure. The mask was refined and improved upon during the course of World War I, and newer models are still being developed today.

The use of mustard agent during World War I was ultimately responsible for the majority of casualties

from the war. By targeting the skin, eyes, and lungs, mustard rendered a large number of soldiers ineffective as part of the fighting force. The grotesque pattern of injury that resulted from exposure had a major psychological impact, demonstrating that a chemical weapon need not be lethal to be strategically effective. During this period, mustard agent became known as "the king of war gases."

In 1918 lewisite was produced in the United States, but large-scale production and stockpiling came too late for it to be used in the war. However, lewisite eventually became the primary vesicant stockpiled by the Soviet Union. Meanwhile in France and Austria, experiments with cyanide produced mixed results. Cyanide was novel because it produced nearly instant incapacitation and was highly lethal. However, its nonpersistent properties and low specific gravity made it unsuitable for the open field and trench environment of the day.

By World War II, Germany had made tremendous progress with the innovation of agents toxic to the nervous system. The G-series nerve agents, such as tabun (North Atlantic Treaty Organization [NATO] designation: GA) and sarin (NATO designation: GB), featured the instant incapacitation and lethality of cyanide and were effective at much lower concentrations. The G-series agents also had superior dispersal characteristics. These new nerve agents were not used during the war, though, and the Allies discovered them and developed countermeasures only after the conflict.

From the Cold War to Disarmament

During the Cold War, the United Kingdom invented the V-series nerve agents, which were weaponized by the United States and Soviet Union. V-series nerve agents are toxic in even smaller doses than G agents and are persistent in the environment. They were considered an ideal area denial weapon by both the western powers and the Eastern Bloc.

The 1960s was a period of experimentation using incapacitating and psychedelic agents that impaired combat performance without being lethal. During the 1970s and 1980s, the Soviet Union continued to increase the size of its chemical stockpile and initiated a massive program named "Foliant" to produce newer and deadlier agents.

During the Reagan administration, the United States produced a binary chemical weapon deterrent. Binary weapons are chemically identical to traditional nerve agents, but differ in that the final chemical reaction occurs only after a projectile is fired, allowing safe storage and transportation of the weapon.[1] Simultaneously, during the Iran/Iraq war, mustard agent returned to the battlefield, and an incapacitating agent similar to 3-quinuclidinyl benzilate (often called "BZ," a glycolate anticholinergic) named "Agent 15" was developed.

The Current Age

The results of the 1993 Paris Convention, known as the "Chemical Warfare Convention," were in effect by 1997 and resulted in a period of disarmament by nation-states. Meanwhile, terrorist organizations developed interests in chemical weapons and had some success in producing and employing them. The most recent public application of chemical warfare occurred in 2002 at the Nord-Ost Moscow theater. In an attempt to free 850 hostages being held by Chechen rebels, the Russian government used a supposedly opiate-based incapacitating agent called Kolokol-1, which resulted in the deaths of 42 terrorists and at least 129 hostages. Another concerning development was noted when dissident scientist Vladimir Mirzayanov publicly stated that his country was circumventing the Chemical Warfare Convention by developing a new generation of nerve agents.[2–4]

Readers interested in more information on the historical aspects of chemical warfare can find the information in chapters 2 through 4. These chapters offer a thorough review of the history of chemical warfare, the medical management of chemical casualties, and the chemical threat.

THE CURRENT THREAT OF CHEMICAL PROLIFERATION

The Chemical Warfare Convention now includes 181 signatory countries.[5] Since it became effective in 1997, some progress destroying large chemical arsenals has been made.

Managing the Stockpile

The global declared stockpile of chemical weapons is about 70,000 tons. Of this, the stockpile declared by the United States is 30,599 tons of unitary agent and 680 tons of binary components.[6] As of 2007, about half of the US stockpile has been destroyed: two of seven chemical demilitarization facilities have completed their destruction missions.[7] Russia has had a more difficult time destroying its declared 40,000 tons of agent, which consists largely of nerve agent and lewisite.[8] The reportedly poor security of storage facilities and the very slow pace of demilitarization pose a challenge for both Russia and the international community.[9] These conditions may present an unin-

tended proliferation risk.[10] Further details about the global stockpile and demilitarization are presented in Chapter 4.

The Terrorist Threat

It is well known that terrorists have a strong interest in chemical weapons. For example, in 1995 several followers of the Aum Shinrikyo cult carried out a nerve agent attack with sarin in the Tokyo subway system. The media has reported that Al Qaeda and its operatives have also had a fascination with weapons of mass destruction, including chemical weapons. Of particular concern are revelations that Al Qaeda had plans to employ cyanide devices against civilians in New York City subways.[11] Several cyanide plots have been thwarted prior to execution, yet plans for a crude but potentially effective cyanide dispersal device have been posted on jihadist Web sites since 2005.[12] Because the next chemical attack may occur in the civilian arena, there are implications for both the civilian first responder and for the armed forces. The military may be called upon for consultation or response in such a situation, making it necessary for it to work with civilian populations.

The Future Chemical Threat

There are myriad toxic chemicals that could be considered agents of concern for the future chemical threat. Also, the possibility that existing classes of agents may be enhanced for more lethal effects must always be considered so that countermeasures are developed. The potential future chemical threat is as wide ranging as an adversary's imagination and budget allow.

JOINT MEDICAL LIFECYCLE MANAGEMENT

In 2003 the US Army was made the executive agent for the chemical/biological program to coordinate and integrate all research, development, and acquisition programs for all the services. As of 2007 the program includes the Joint Program Executive Office (JPEO), the Joint Science and Technology Office, the Joint Test and Evaluation Executive Office, the Joint Combat Developer, and the Joint Requirements Office. These offices are dedicated to delivering joint fighting capabilities, including medical treatment.

To counter the chemical threat, sustain combat power, and maintain a healthy force, the military established the JPEO in April 2003. The JPEO integrates a systems approach to address agent delivery, doses on target, downwind dispersal, dose absorbed, and symptoms. The Chemical Biological Medical Systems Joint Project Management Office is specifically responsible for medical systems. It addresses chemical casualty medical pretreatment and posttreatment, medical surveillance, and medical diagnostics to counter the threat and leverage the joint services research and development programs for combat personnel.

The Chemical Biological Medical Systems Joint Project Management Office is responsible for developing, procuring, fielding, and sustaining premier medical protection and treatment capabilities against chemical and biological warfare agents. Medical products are submitted through the US Food and Drug Administration for licensing or approval. The management office is composed of a headquarters and support element and two joint product management offices: the Joint Vaccine Acquisition Program (which focuses on developing, testing, producing, and storing vaccines) and Medical Identification and Treatment Systems.

Medical Identification and Treatment Systems manages the development, acquisition, and fielding of products used for the prophylaxis, treatment, and diagnosis of chemical and biological warfare agent exposure in US service members. Medical Identification and Treatment Systems products range from specific hardware devices that enable medical personnel to diagnose biological warfare agent exposure to drugs that prevent or mitigate the actions of chemical or biological agents.

Science and technology (research and development) is overseen by the Defense Threat Reduction Agency chemical/biological directorate. The Defense Threat Reduction Agency must interact at many levels, including with the executive agent or the Army acquisition executive (who takes direction from the defense acquisition executive), the Joint Requirements Office (which addresses user community needs and requirements), the deputy assistant to the secretary of defense for chemical and biological programs (which provides program oversight), the Joint Staff, the US Army Chemical School, the joint program managers, and the JPEO. The medical mission of the Defense Threat Reduction Agency is to safeguard America and its allies from weapons of mass destruction (chemical, biological, radiological, nuclear, and high-yield explosives) by providing medical capabilities to reduce, eliminate, and counter the threat and mitigate its effects. The Defense Threat Reduction Agency manages the medical research and development programs and funding, including the Department of Defense medical missions at the US Army Medical Research Institute of Infectious Diseases and the US Army Medical Research Institute of Chemical Defense (USAMRICD).

THE ROLE OF THE US ARMY MEDICAL RESEARCH INSTITUTE OF CHEMICAL DEFENSE

USAMRICD is the lead Department of Defense laboratory dealing with the medical aspects of chemical defense. It focuses on medical research, training, and education for medical chemical defense. USAMRICD activity involves basic research, clinical studies, therapeutics, and other areas of research. USAMRICD also partners with major military and civilian organizations throughout the country and abroad.

Development of Medical Countermeasures

USAMRICD builds on basic research to support soldiers through the development of medical countermeasures and therapeutics. Current projects include the use of both simple and catalytic bioscavengers for prophylaxis and treatment of nerve agent casualties. Additional research areas of interest include the new oximes and neuroprotective compounds that mitigate the effects of nerve agent exposure. Studies investigating the use of midazolam as a new generation nerve anticonvulsant are in advanced stages. There is an increase in medical vesicant research to indentify the specific biochemistry of injury as well as to develop novel protectants and treatments. Cyanide and pulmonary agent research has been increasing in pace as well. Other work at USAMRICD involves developing medical diagnostics and personnel decontamination research. Work on equipment and detection gear is conducted by USAMRICD's partner institute, the Edgewood Chemical Biological Center.

Education and Educational Products

The chemical casualty care division is responsible for training military medical personnel in the practice of medical defense, medical decontamination, and triage. It also provides education for other military branches, civilians, government agencies, and foreign nationals. Courses are accredited as continuing medical education for physicians, nurses, and emergency medical technicians, and for college credit.

The courses taught onsite at the chemical casualty care division include the Medical Management of Chemical and Biological Casualties Course, which is produced jointly with the US Army Medical Research Institute of Infectious Diseases. The course consists of lectures, a field exercise, and a unique primate lab experience. It has been recognized as the gold standard for this type of training by the Office of The Surgeon General and the Government Accountability Office. Other courses include the Field Management of Chemical and Biological Casualties, which targets front echelon care. This course includes multiple field exercises to encourage proficiency in the field medical decontamination station. The Hospital Management of Chemical Biological Radiological Nuclear and Explosives Course is a preparatory course for mass casualty chemical, biological, radiological, nuclear, and explosives events. It includes instruction on regulations regarding these events and cooperation with civilian and military authorities at other echelons.

The chemical casualty care division is responsible for a large volume of educational products. These products include publication content for educational materials as well as pocket manuals for the field management of chemical casualties and medical management of chemical casualties. The chemical casualty care division produces several software products, such as reference materials, distance and online training courses, educational games, and interactive simulations.

ORGANIZATION OF THIS VOLUME

Awareness and interest in weapons of mass destruction, medical chemical defense research, and education and training of military personnel and civilians has increased dramatically in the last few years. The need for an updated and resultant text dedicated to the medical aspects of biological and chemical weapons would not fit into a single textbook. Hence, this text differs from the earlier version of the *Textbooks of Military Medicine: Medical Aspects of Chemical and Biological Warfare* because biological and chemical agents are discussed in separate volumes. This text is primarily relevant to military medicine; however, due to the increased interest in chemical casualty treatment that now exists within civilian communities, the information provided within this text can be considered an excellent resource for both military and civilian healthcare providers.

Chapters 2 through 4 offer greater depth concerning the history of chemical warfare and the basic principles of chemical warfare. "History of Chemical Warfare" takes a broad view of the historical context and significant events in the field. "History of the Chemical Threat" breaks the 20th century down into decade-long segments and provides a fresh perspective on prior military and political developments. "The Medical Aspects of Medical Management" chapter has radically changed over the years and presents this history from multiple perspectives. It includes detailed accounts of the chemical warfare management experience in

the United States, as well as a revealing exploration of British, Canadian, French, Russian, and German experiences.

Chapters 5 through 7 concentrate on nerve agents. Chapter 5 is a comprehensive treatise on the present research, countermeasures, physiology, and management of nerve agent casualties. The chapter on neuroprotection (Chapter 6), new to this volume, reviews developments in protective adjuncts to classic nerve agent antidote therapy. Chapter 7, also new, examines the emerging field of therapeutics that may represent the next advancement in therapy for these casualties.

Chapters 8 through 15 cover the remaining categories of threat agents. Vesicants are presented in historical, clinical, and physiological detail in Chapter 8, and Chapter 9 has been updated with the most current clinical data in the field. Given the increased nonstate and terrorist threat from chemical weapons, the chapter on toxic industrial chemicals has been broadened (Chapter 10). Cyanide appears to be of major interest to terrorists and the civilian population, so Chapter 11 has been expanded in size and scope. Two chapters devoted to nonlethal agents are also covered in this section.

Chapters 16 through 19 are concerned with the field management, triage, and decontamination procedures within the US military. Current and new equipment are described in detail. The final section of the book relates to partnering, acquisition, and preparedness and includes an entirely new chapter dedicated to the medical management of pediatric casualties. There is also a chapter devoted to medical diagnostics (Chapter 22).

SUMMARY

The chemical warfare threat to the United States has changed dramatically in recent years, becoming less obscure. Chemical weapons that are being destroyed under the Chemical Warfare Convention by major nation -states are increasingly attractive to pariah states and terrorists. In the current environment, the United States may experience a higher likelihood of a chemical attack on its military forces and civilian population, more so than ever before in the history of chemical warfare and terrorism.

Given the changing chemical threat, this textbook has broadened in scope and depth and now encompasses an entire volume. This expanded text attempts to be a comprehensive guide to the full spectrum of these agents and to provide information on the state of the art in medical therapeutics.

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