

# Chapter 14

## FIELD MANAGEMENT OF CHEMICAL CASUALTIES

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## INTRODUCTION

The management of casualties exposed to chemical, biological, radiological, and nuclear (CBRN) agents has long been part of military doctrine. Since the events of September 11, 2001, interest in the management of these types of casualties has extended to the civilian response network. The military mission has likewise expanded beyond the battlefield to include operations in support of homeland defense and humanitarian disaster relief. This expansion of military roles has not significantly changed the procedures for chemical casualty care. Although specific medical and decontamination equipment has changed with time, the core principles for managing contaminated casualties remain basically unchanged since World War I, when the treatment of chemical casualties was conducted on a large scale. These core principles include the early removal of hazardous agent from patients to reduce injury and contamination spread, and the provision of early and effective life-saving treatment.

To save the lives of those contaminated by hazardous agents, medical care providers, whether civilian or military, must be capable of a rapid and effective response. This involves first responders providing initial medical intervention in the contaminated area, or on the periphery, while wearing protective equip-

ment. First responders, as well as first receivers (those who receive contaminated patients at the hospital), must have the training to carry out patient triage and life saving treatment for contaminated patients before, during, and after decontamination. This method of casualty management will reduce injury and should significantly reduce the health impact of a mass casualty event caused by the release of hazardous substances.

This chapter compares the current field management operations of the various military services (land-based and sea-based forces) and the civilian medical community. Although patient treatment strategies still vary, there are now many similarities in the decontamination procedures used by these various organizations, with key differences related to the platforms on which field management takes place (eg, on land vs. on sea-going vessels) and the specific equipment used for medical care, transport, and decontamination. The emphasis in this text is on the management of chemical casualties; however, these same processes are equally applicable to treating patients affected by biological and radiological contaminants. Doctrine and techniques continue to be upgraded, but it is expected that any future developments should continue to follow the basic principles discussed here.

### HEALTH SERVICE SUPPORT AND MILITARY FORCE HEALTH PROTECTION ON THE BATTLEFIELD

Health service support (HSS) includes all services performed, provided, or arranged by the military services to promote, improve, conserve, or restore the mental or physical well-being of personnel.<sup>1</sup> Military doctrine and terminology are rapidly changing to better support joint operations both on the battlefield and in civil support missions at home and abroad. This brief overview of current and developing doctrine focuses on its application to the management of chemical casualties across the military.

Force health protection (FHP) consists of measures taken by all military members, from commander to the individual service member, to promote, improve, conserve, or restore mental and physical well-being of personnel.<sup>1</sup> FHP, the medical component of force protection, is a comprehensive approach to care that includes proactive medical services, striving to prevent casualties instead of focusing only on postcasualty intervention.<sup>1</sup> The basic objectives of military HSS and FHP are to promote and sustain a fit and healthy force, prevent injury and illness, protect the force from health threats, and sustain medical and rehabilitative care. The newer, more comprehensive, focus on FHP consists of three pillars of health protection (Figure 14-1), providing a continuum of military health care

before, during, and after military operations.<sup>1</sup>

On the battlefield, medical care focuses on

- minimizing the effects of wounds, injuries, disease, environment, occupational hazards, and psychological stressors on unit effectiveness, readiness, and morale; and
- returning to duty as many service members as possible at each level of care.<sup>2</sup>

These objectives also apply when the military assists in homeland defense operations in support of local and state assets during a national emergency. Military and civilian HSS planning includes the medical response to CBRN agent threats.

In any setting, far-forward medical treatment is critical to reduce injury and save lives. Military medicine focuses on this far-forward care, provided initially by the military member or a fellow unit member (a "buddy"), and efficient casualty evacuation to medical facilities offering the appropriate care.<sup>2</sup> Table 14-1 gives an overview of the new taxonomy of care capabilities, comparing them to the current concept of levels (echelons) of care particular to the management of chemical casualties.<sup>1,2</sup>

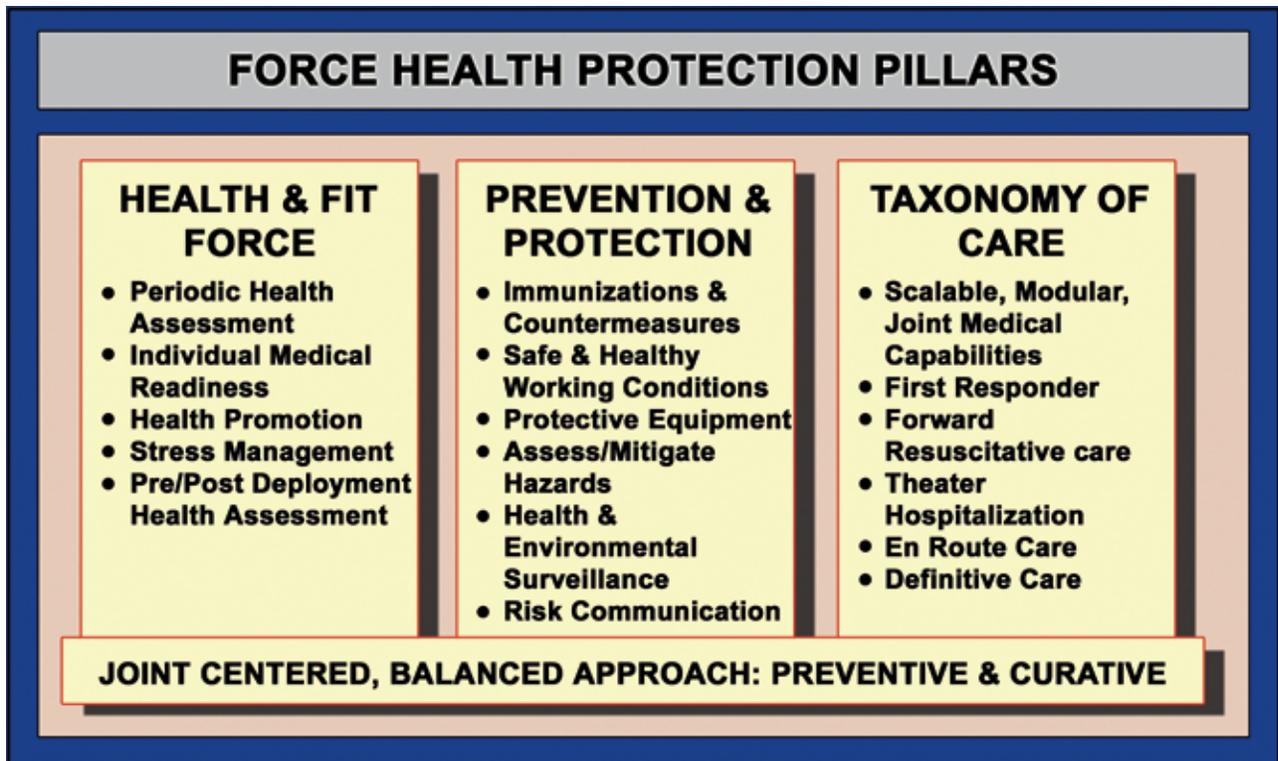


Fig. 14-1. The pillars of force health protection.

Reproduced from: US Department of Defense. *Health Service Support in Joint Operations*. Revision, Final Coordination. Washington, DC: DoD; 2005. Joint Publication 4-02: 1-9.

## SERVICE-SPECIFIC OPERATIONS FOR FIELD MANAGEMENT OF CHEMICAL CASUALTIES

### Land-Based Forces

Land-based forces are comprised primarily of US Army and Marine Corps (USMC) personnel, land-based Navy personnel in support of land forces, and Air Force personnel in support of air operations and land forces. Land-based forces include all levels of HSS. HSS units from all services plan and train for chemical agent incidents in advance. In joint operations, all of the services move battlefield casualties through the taxonomy of care (Figure 14-2), with various service components having responsibility for particular treatment facilities as dictated by the Joint Task Force (JTF) commander.

The first responder capability (level I) for Army land-based forces at the point of injury incorporates self and buddy aid care. Units also have combat medics or treatment squads that provide first aid. Unique to the Army at this level is the combat life saver, a soldier with first-aid training. These individuals are capable of assisting the medic in field care of injured soldiers. The battalion aid station (BAS) is also part of this capability. Stabilization and emergency treatment for a limited

number of contaminated casualties can be achieved at the BAS depending on its available resources to decontaminate the patients before admission to the BAS. Casualties with injuries that require further treatment, or who cannot be managed at the BAS, are evacuated to the area support medical battalion or to units capable of forward resuscitation care (FRC), which include forward surgical teams. Forward surgical teams cannot operate in a chemical environment unless supported by a unit such as the division clearing station, which provides the capability to decontaminate patients.<sup>3</sup> The operational tempo may not allow for the thorough decontamination of patients by first responders (level I) or units with an FRC capability (level II); therefore, medical facilities serving in a theater hospital capability (level III and IV) must be prepared for the triage and decontamination of contaminated casualties who are transported dirty (without thorough decontamination) to their facilities. The combat support hospital is the Army theater hospital asset that provides surgical care, laboratory services, and stabilization of chemical casualties. Army field medical facilities can be chemically hardened with chemically resistant inner tent

**TABLE 14-1**

**COMPARISON OF TAXONOMY OF CARE CAPABILITIES WITH LEVELS (ECHELONS) OF CARE PARTICULAR TO CHEMICAL CASUALTY MANAGEMENT\***

<i>Care Capability / Level of Care</i>	<i>Care Rendered</i>	<i>Care Particular to Chemical Casualties</i>
<p><i>First Responder Capability</i></p> <p>Compares to level I care at the unit level. Prepares patient for return to duty or transport to the next level of care.</p>	<p><i>Initial essential stabilizing medical care rendered at the point of injury.</i></p> <p>Self aid, buddy aid, examination, emergency lifesaving (eg, maintain airway, control bleeding, prevent shock). Use of IV fluids, antibiotics, applying splints and bandages.</p>	<p>Same as care rendered plus:</p> <ul style="list-style-type: none"> <li>• Decontamination of the skin and equipment.</li> <li>• Providing antidotes (atropine/2 PAM/diazepam) to chemical agents.</li> </ul>
<p><i>Forward Resuscitative Care Capability</i></p> <p>This compares to level II physician-directed emergency care at a small medical facility in the theater of operations. Treat patient for RTD or stabilize for movement to a larger medical treatment facility capable of providing care.</p>	<p><i>Forward advanced emergency medical treatment performed as close to the point on injury as possible, based on current operational requirements.</i></p> <p>Resuscitation and stabilization, can include advanced trauma management, emergency medical procedures, and forward resuscitative surgery. May have capability (depending on military service) for basic laboratory, limited radiograph, pharmacy, type O blood transfusion, and temporary holding facilities.</p>	<p>Same as responder capability (level I) plus:</p> <ul style="list-style-type: none"> <li>• Emergency contaminated shrapnel removal.</li> <li>• Intubation.</li> <li>• Ventilatory support (though limited).</li> <li>• Wound debridement.</li> <li>• Informal stress counseling.</li> </ul>
<p><i>En Route Care Capability</i></p>	<p><i>Involves the medical treatment of injuries and illnesses during patient movement between capabilities in the continuum of essential care.</i></p>	<p>New term not used in former doctrine. Includes support of airway, controlling bleeding, and administration of antidotes and seizure medications, if needed and available during transport.</p>
<p><i>Theater Hospitalization Capability</i></p> <p>Compares to level III and IV capabilities Facility in theater that is larger than FRC (level II). Care requiring expanded clinical capabilities such as restorative surgery. Treat patient for RTD or begin restorative surgery and prepare for movement to a higher level of care.</p>	<p><i>Includes theater hospitals with modular configurations to provide in-theater support and includes the HSS assets needed to support the theater.</i></p> <p>Resuscitation, initial wound surgery, and postoperative treatment. This is the first level that offers restorative surgery and care rather than just emergency care to stabilize the patient. Has larger variety of blood products than level II.</p>	<p>Same as for FRC (level II) plus:</p> <ul style="list-style-type: none"> <li>• Exploratory surgery.</li> <li>• Initial burn care .</li> <li>• Bronchoscopy.</li> <li>• Intubation.</li> <li>• Ventilatory support (more assets than level II).</li> <li>• More extensive wound debridement.</li> <li>• Eye care.</li> <li>• Respiratory therapy.</li> <li>• Formal stress counseling.</li> </ul>
<p><i>Level IV</i></p> <p>Largest facility found in mature theaters. Rehabilitates those who can RTD in theater and prepares more serious casualties for movement to level V.</p>	<p>Provides restorative surgery, like level III, and also rehabilitative and recovery therapy.</p>	<p>Same as for level III plus:</p> <ul style="list-style-type: none"> <li>• Physical and occupational therapy rehabilitation for those with limited vesicant burns.</li> <li>• Full respiratory therapy .</li> <li>• Ventilatory support (more assets than level III).</li> <li>• More extensive eye care.</li> <li>• Psychological counseling.</li> </ul>

(Table 14-1 continues)

Table 14-1 continued

*Definitive Care Capability*

Compares to a stateside level V.

Definitive care, which is normally provided in the continental United States, Department of Veterans Affairs hospitals, or civilian hospitals with committed beds for casualty treatment as part of the National Defense Medical System. May also be provided by overseas allied or host nation MTFs

*Care rendered to conclusively manage a patient's condition, includes the full range of acute, convalescent, restorative, and rehabilitative care sites outside the theater of operations.*

Includes the full range of acute convalescent, restorative, and rehabilitative care.

Same as for level IV plus:

- Longer term respiratory therapy.
- Full rehabilitative services for mental health, cognitive/memory retraining, retraining in activities of daily living/life skills, prevocational services, and post traumatic stress counseling. This incorporates a team of rehabilitation professions such as physical, occupational, speech, and mental health services as needed based on the severity of exposure and resulting disability, if any.

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\*Taxonomy of care terms are in italics.

FRC: forward resuscitative care

HSS: health service support

IV: intravenous

2-PAM: 2-pyridine aldoxime methyl chloride

RTD: return to duty

Data sources: (1) US Department of Defense. *Health Service Support in Joint Operations*. Revision, Final Coordination. Washington, DC: DoD; 2005. Joint Publication 4-02. (2) US Department of Defense. *Doctrine for Health Service Support in Joint Operations*. Washington, DC: DoD; 2001. Joint Publication 4-02.

liners and fitted with air filtering units.

Land-based Naval units are divided into broad warfare areas including expeditionary warfare, forces that move to a theater of operations, and naval installations.<sup>4</sup> Expeditionary units include construction forces, logistic support personnel, special warfare units, and fleet hospitals. Expeditionary forces on land are typically deployed in support of USMC units. These usually include land-based FRC (level II) capability, which may initially contain as few as 10 beds but can be expanded to 500 beds with a theater hospitalization capability (ie, a combat zone fleet hospital).<sup>1</sup> Casualties from these facilities can then be evacuated to land-based facilities of other services or to hospital ships. Expeditionary medical units deploy as part of a landing force, with CBRN defense capabilities for individual protection, self-decontamination, and limited equipment decontamination.

Naval installations such as fleet hospitals, on the other hand, are more permanent, fixed facilities that offer FRC capabilities at level III or greater. Installation planning at these facilities involves disaster preparedness, including coordination with local authorities. Plans for operations in a contaminated environment include using shelter-in-place procedures, individual protective gear, and various types of detection equipment. The installation disaster officer directs emer-

gency-response teams, coordinates decontamination operations, and assists in the command and control operations center.<sup>4</sup> In addition to triage and treating casualties from an incident, the medical department also organizes medical supplies; provides food and water inspection; conducts disease monitoring; distributes antidotes and medications as needed for CBRN incidents; and provides training on CBRN hazards, self aid, and first aid as part of FHP.<sup>4</sup>

The approximately 175,000-member USMC is an intrinsic part of the Department of the Navy; medical support to the Marine Corps is provided by the Navy Medical Department. USMC personnel may augment Navy medical patient decontamination operations. First responder capability (level I) is provided through self aid and buddy aid as well as by Navy corpsmen assigned to USMC units. The Marines, at this level, also utilize their intrinsic BASs, or USMC wing support squadron aid stations, staffed by Navy medical personnel. Unique to the USMC is the Chemical/Biological Incident Response Force (CBIRF) with first responder medical capabilities. CBIRF deploys domestically, particularly in the National Capital Region of Washington, DC, or overseas to pre-position or respond to a CBRN incident. Composed of USMC and Navy personnel, CBIRF has the capability to monitor, detect, identify, and analyze toxic industrial chemicals (TICs), toxic

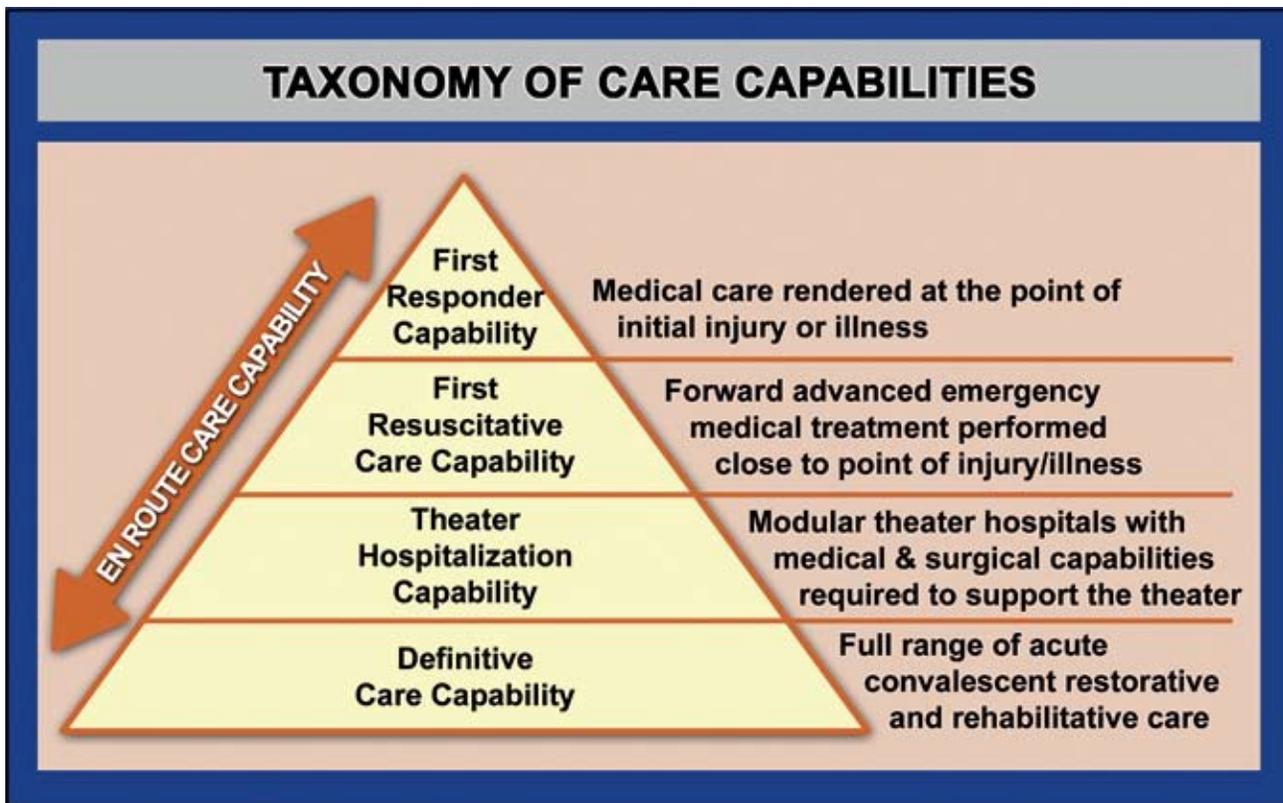


Fig. 14-2. Taxonomy of care capabilities.

Reproduced from: US Department of Defense. *Health Service Support in Joint Operations*. Revision, Final Coordination. Washington, DC: DoD; 2005. Joint Publication 4-02: I-4.

industrial materials, and other CBRN hazards. The force has casualty extraction teams, technical search and rescue teams, and patient/responder decontamination assets to support a mass casualty incident. CBIRF medical personnel are trained to conduct triage and provide emergency medical care to stabilize large numbers of contaminated casualties extracted from the incident site; then decontaminate them for transfer to local medical facilities.<sup>4</sup>

Air Force first responder capability (level I) consists of self aid and buddy care.<sup>5</sup> First responders then retrieve the patient and form a casualty collection point for transport to the base medical facility. The Air Force incorporates the split mission-oriented protective posture (MOPP) concept, dividing an air base into sectors or control zones, each operating under a different MOPP level depending on its contamination threat. Under this plan, one area of the base may be contaminated without affecting the operations of the entire base.<sup>6</sup> Casualties are retrieved from the contaminated zones by medical first responders in protective ensemble and transported to the base medical facility or base casualty holding area. Depending on the maturity

of the base, the medical support can consist of a small portable expeditionary aeromedical rapid response package, a basic Expeditionary Medical Support (EMEDS) package, or a larger EMEDS plus 10- or 25-bed package, which evolves into an Air Force theater hospital. Casualty care includes patient decontamination, triage, clinical care, movement or quarantine on the air base, and aeromedical evacuation.<sup>7</sup> EMEDS can be configured to have an FRC capability (level II) or a theater hospital capability (level III or IV) based on the number of air-transportable medical equipment and personnel packages deployed to meet operational requirements. EMEDS equipment packages consist of tentage and medical equipment that can be added to an EMEDS basic package to increase service and bed capacity. The EMEDS basic package can be deployed as a “collectively protected” Air Force medical facility to provide shelter in a chemically or biologically contaminated environment.<sup>7</sup> In these collective protection configurations the EMEDS facilities are fitted with chemical protective liners and air handling units that filter hazardous agents. An EMEDS facility is designed to remain in operation for days after a chemical attack

on the base. When collectively protected, a small-shelter patient decontamination system package is added to provide the capability to decontaminate large numbers of patients before they enter the collectively protected EMEDS.<sup>8,9</sup>

For all services, evacuation of land casualties is performed by the facility at the next higher level of care, which sends evacuation assets forward to retrieve the patient. Patient movement is typically carried out by rotor-winged aircraft or ground vehicles. In theater this is normally the responsibility of either the service component command that operates the particular facility or Army rotor-wing medical evacuation (MEDEVAC) units.<sup>1,5</sup> These units may have to designate certain assets to transport contaminated casualties from a chemical battlefield to an FRC or theater hospital. Fixed-wing Air Force aeromedical assets used for intertheater evacuation are usually reserved for patients who have been decontaminated.<sup>1,5</sup>

### Sea-Based Forces

Sea-based forces are comprised primarily of Navy and Coast Guard assets. Medical evacuation to Naval vessels operating offshore must certainly be considered for chemical casualties with airway compromise or significant trauma. Army air ambulance, Navy, or USMC casualty evacuation helicopters provide the rotor-wing assets for these vessels (Figure 14-3).<sup>1</sup> In the Navy, the major designated casualty receiving and treatment ships are the dozen multipurpose large-deck amphibious landing helicopter dock assault ships of



**Fig. 14-3.** Unloading a patient from Army MEDEVAC to a Navy ship for treatment.

Reproduced from: US Department of Defense. *Health Service Support in Joint Operations*. Revision, Final Coordination. Washington, DC: DoD; 2005. Joint Publication 4-02.

the USS *Wasp* class, such as the USS *Bon Homme Richard* or USS *Kearsage*.<sup>10</sup> These large, 40,000-ton vessels, 823 feet long, are designed to operate offshore in support of amphibious operations and can serve as FRC (level II) facilities.<sup>5</sup> They support intense helicopter activities and are designed around large, self-contained “well decks” for small boat transfers within the protected hull of the ship. Extensive command, control, communication, and computer capabilities allow for MEDEVAC coordination and patient regulating. The newly commissioned landing platform dock 17, San Antonio-class amphibious ships have similar capabilities but a smaller size.<sup>10</sup> These Naval platforms, connected locally with helicopter assets, can be combined with the extended 1,500-mile range of the V-22 Osprey vertical takeoff and landing aircraft to bring multiple capabilities for medical response to the severely injured, whether they have chemical or physical trauma. The medical facilities on Navy aircraft carriers provide FRC (level II) capability, although their space is limited compared with that of the casualty receiving and treatment ships.<sup>5</sup> The casualty receiving and treatment amphibious assault vessels are large floating facilities, with FRC (level II) capability available to land-based forces or civilian casualties during presidentially authorized military support to civil authorities.

Although they lack an enclosed “well deck” for efficient small boat transfers, the two 70,000-ton hospital ships USNS *Comfort* and USNS *Mercy* (Figure 14-4) have large helicopter landing pads and offer complete tertiary care capabilities, including 12 operating rooms, 80 intensive care beds, and 50 ventilators, providing the services of a theater hospital (level III). Naval facilities



**Fig. 14-4.** Hospital ship USNS *Mercy*.

Reproduced from: US Department of Defense. *Health Service Support in Joint Operations*. Revision, Final Coordination. Washington, DC: DoD; 2005. Joint Publication 4-02: III-12.

capable of providing a definitive care capability (level IV and V) are located outside the theater of operations in large land-based installations.<sup>1,11,12</sup>

In contrast, the Coast Guard has limited capabilities to receive casualties. Coast Guard personnel can provide first aid for victims rescued from ships or the water. The primary Coast Guard role is to offer force protection and safety regulation for vessels and ports, to minimize the possibility of a chemical attack or major toxic industrial chemical incident. Their much smaller 300-foot Coast Guard cutters are staffed by independent duty corpsmen and physician's assistants capable of providing first aid for chemical casualties, including administration of atropine autoinjectors and basic decontamination with water, soap, and hypochlorite solutions. These medical assets can also participate as part of requested federal resources in response to a mass casualty event. The Coast Guard deep-draft vessels scheduled to enter operation in 2007 will have capabilities to operate in a chemical hazard environment for up to 72 hours.<sup>13</sup>

Medical response planning and evacuation of casualties to ships is the responsibility of the JTF surgeon, a physician of any specialty, usually embarked on the

lead ship and a staff member of the JTF Commander. The JTF Commander, usually at least a one-star admiral, is responsible for coordination of Naval assets in support of land-based objectives of the operational theater commander. During shore-to-ship operations, the Army is usually responsible for medical rotary-wing support for patient transport; otherwise the Navy and USMC perform this service. The Air Force is the principal fixed-wing air asset for the transportation of patients from the theater of operations to the continental United States (ie, to level V) during joint operations.<sup>5</sup>

By doctrine, patients must be decontaminated before transport to Naval vessels; however, a thorough decontamination of patients may not be possible with a high operational tempo. Navy documents provide detailed instruction for the decontamination and processing of patients brought on board ship by rotor-winged aircraft and landing craft before they are brought below decks.<sup>14</sup> Large Navy vessels at sea have extensive water supplies for decontamination purposes. Their evaporators daily produce thousands of gallons of fresh water. Additionally, appropriately protected personnel can quickly use fire hoses to wash down external areas with salt water.

## MANAGEMENT OF CHEMICAL CASUALTIES FROM A CIVILIAN PERSPECTIVE

The accidental release of toxic substances occurs regularly in the United States from fixed storage and industrial facilities and from containers during transportation. Most common among these substances are ammonia, pesticides, volatile organic compounds, acids, and petroleum products.<sup>15</sup> US hazardous materials (HAZMAT) response teams have gained experience in managing these accidental releases. Events such as the 1984 release of the carbaryl pesticide precursor methylisocyanate, in Bhopal, India, which killed and injured thousands, and the more limited yet lethal attacks by the Aum Shinrikyo cult in Matsumoto (1994) and later Tokyo (1995), Japan, killing less than a dozen but injuring scores more, demonstrate that intentional acts of sabotage and terrorism can create large numbers of casualties in unprotected civilian populations.<sup>16-18</sup>

Until recently, no effort had been made to standardize guidelines for the management of mass casualties from such events. In February 2003, Homeland Security Presidential Directive-5 was signed into law by President George W Bush, initiating the development of the National Incident Management System.<sup>19</sup> This system serves as the template for the management of mass casualty events in the United States, whether they are caused by a terrorist attack, accident, or natural event (such as a hurricane). It provides a framework to coordinate the response of the government, private-

sector, and nongovernmental organizations. Structure is added to this framework through the National Response Plan (NRP), which provides the actual coordination mechanisms for various agencies, including fire, rescue, and emergency medical services, for effective communication and teamwork.<sup>20</sup> These documents, along with others developed by the Department of Homeland Security, Department of Health and Human Services, Occupational Safety and Health Administration (OSHA), Joint Commission on Accreditation of Hospital Organizations, and other agencies, have sought to foster more standardization in the disaster and medical response to mass casualty events from all hazards. This entire response plan was first fully implemented in response to Hurricane Katrina, which devastated the US Gulf Coast in August 2005, and is undergoing further modification based on the many lessons learned from the disaster.

Local responses to chemical releases vary. Typically, when a casualty-causing chemical event occurs, those who can flee the scene on foot or by private or commercial vehicle are the victims first seen at the nearest medical facility. As demonstrated in Tokyo, their arrival may be the first indicator for a medical facility, and a community, that an event has occurred.<sup>21,22</sup> When the event is reported to authorities, local fire departments and HAZMAT teams, if

available, respond. Response time can range from 5 to 30 minutes from initial release.<sup>23,24</sup> Once these teams respond, the area is cordoned off. Decontamination units are established by the fire department at the periphery of the contaminated area (the hot zone). The initial processing of patients through decontamination can be 30 minutes or more after the initial toxicant release.<sup>23</sup> In some communities, particularly in rural areas, medical personnel do not have level II emergency medical service (EMS) or hazardous materials operations training, so they cannot accompany HAZMAT crews into contaminated areas. Frequently, local EMS personnel are not proficient in treating contaminated patients while wearing personal protective equipment (PPE), which relegates them to treating patients after decontamination.<sup>25</sup> Wearing appropriate self-protection ensemble while stabilizing patients before decontamination procedures is a difficult challenge for first responders. Victims are often decontaminated and only then seen by unprotected EMS personnel, who place them on ambulances for transport to hospitals. Because HAZMAT teams must take time to secure the area and muster equipment before they can begin decontamination, victims who do not flee the scene before the arrival of HAZMAT and fire department teams may not receive medical care for 30 minutes or more after their exposure.<sup>23</sup> A sequence of events similar to this occurred after passive release of dilute sarin nerve agent in the 1995 Tokyo attack.<sup>17</sup> Authors such as Okumura who studied this event closely believe that a more forward medical presence, as incorporated by the military, may save

more lives in the event of a chemical release creating mass casualties, particularly if a potent warfare agent is used in the attack.<sup>17</sup>

Currently, many larger metropolitan fire departments are training their emergency medical technicians (EMTs) to provide life saving medical care in the contaminated area or at its periphery. This training still does not occur in many smaller rural departments, or in most private emergency services, which provide care only after patient decontamination. Without adequate first responder training in the provision of medical care while wearing PPE, first responder EMTs are relegated to the contamination-free area; in this situation medical intervention will be too late for many victims.<sup>26</sup> The Department of Health and Human Services is considering policy and recommendations to encourage appropriately trained and equipped first responders from all agencies to provide medical care in contaminated areas. The National Fire Protection Association has published standards for the professional competence of EMS responders in hazardous materials incidents.<sup>25</sup> Hospitals that receive contaminated patients now have guidance through the *OSHA Best Practices for Hospital-Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances*, released in January 2005. This document establishes the baseline for medical facility response to the arrival of contaminated casualties. Its purpose is to insure that the triage, stabilization, decontamination, and treatment of contaminated casualties is successfully conducted while first receiver safety is maintained.<sup>27</sup>

## INTEGRATION OF MILITARY SUPPORT INTO CIVILIAN HOMELAND RESPONSE

The role of the US military in national strategies for defense and homeland security is undergoing rapid development. Specific capabilities within the Department of Defense (DoD) are driven by doctrine and policy promulgated from the Office of the Secretary of Defense and operational orders from regional combatant commanders. These directives shape the forces that are organized, trained, and equipped by the services to support national strategic policies.

The primary role of military medicine, to preserve the fighting force, provides a robust, capable, HSS infrastructure that is mobile, responsive, and trained and equipped for operations in austere environments. This force, which during peacetime provides routine health care for its DoD beneficiaries, must also incorporate the needs and requirements for the post-September 11 homeland defense, the global war on terrorism strategies, and response to requests through the NRP emergency support functions. As the policy and doctrine

drives development of specific capabilities, a balance is required between the goal of smaller, leaner forces with increased operational tempos engaged in supporting the strategies, and a repository of medical response in the homeland for CBRN mass casualty incidents.

Currently, military installations are required to develop and implement CBRN capabilities for response and recovery from terrorist incidents involving weapons of mass destruction (DoD Instruction 2000.18).<sup>28</sup> Capabilities developed for these requirements include detectors; warning and reporting technologies; decontamination equipment; triage and treatment procedures; and command, control, and communication operations. Multiple programs with overlapping capability requirements, including force protection, antiterrorism, and "all hazards" emergency management determine specific capabilities. As all military hospitals subscribe to the Joint Commission for Accreditation of Healthcare Organizations, local coordination for

disaster planning is routinely required.<sup>29</sup> Local and state public health requirements, as well as operational orders from regional combatant commanders, also drive this interactive planning process. The military health system participation in disaster planning for the homeland occurs at city and other local, county, state, federal, and national levels.

After validation of requests by local authorities, commanders may immediately respond to local disasters to save human lives, reduce human suffering, and/or prevent significant property loss.<sup>30-32</sup> Although commanders must notify their chain of command of such actions as soon as reasonably possible, they do not need to seek higher authority before responding.

Medical support to the NRP, emergency support function #8, occurs through defense support of civil authority. Through a bureaucratic process, requests from state governors proceed to the president, then, upon presidential approval, to the coordinating federal agency, generally the Department of Homeland Security for most federally declared emergencies. Requests for DoD assistance are filtered through the

Joint Defense Office of Military Support to ensure that requests are valid and cannot be reasonably met by non-DoD capabilities. The Joint Task Force for Civil Support then serves as the command and control element to match requirements to specific capabilities within the DoD. These assets or units are then “chopped” or change operational command from the service component to the respective regional combatant commander, usually under a specific response task force under the Joint Task Force for Civil Support. These federal assets, such as decontamination teams or medical assistance teams, then operate in support of the local incident commander under the unified command system.<sup>30-32</sup>

Northern Command in Colorado Springs, Colorado, and Pacific Command in Honolulu, Hawaii, represent the regional combatant commanders whose area of responsibility covers the United States and its territories. Operational orders from these commanders, through the service components, determine and influence readiness and response postures for installations under their direction.

## THE MEDICAL MANAGEMENT PROCESS IN A CHEMICAL EVENT

Whether on the chemical battlefield, or in support of homeland defense in response to a terrorist mass casualty event, key measures must be taken to prepare for, manage, and recover from a chemical incident. Although not inclusive, the list below is adapted from guidelines found in several military publications.<sup>3,4,33</sup>

### Preattack, Attack, and Postattack Measures

Preattack, or preparatory, measures include

- understanding potential local chemical threats and specific TICs, their location, specific compounds, and effects;
- preparing plans and equipment to address a chemical agent release, both warfare agents and TICs;
- developing policies to enhance patient field management in the event of a CBRN release;
- training first responders and medical providers in triage and emergency medical care while wearing protective equipment;
- training medical providers in the medical treatment of chemical casualties;
- rehearsing teams in patient decontamination methods and practicing work–rest cycles;
- acquiring appropriate decontamination equipment and PPE;
- designating shelters and practicing collective

protection measures, or sheltering in place, including the use of shelters, recognition of alert states, procedures to disperse assets, and the use of appropriate levels of PPE for medical workers;

- developing and practicing communication with supporting and supported agencies;
- developing and rehearsing logistics to support the management of mass casualty events; and
- developing and rehearsing recovery plans including the management of hazardous waste from patient decontamination operations.

Attack measures, or measures to take during the event, include

- instituting plans for the evacuation and processing of casualties;
- securing medical treatment facility (MTF) entrances to maintain a contamination-free hospital environment;
- practicing individual protection and collective protection for medical and other MTF personnel in potentially contaminated areas;
- performing patient treatment and decontamination;
- instituting work–rest cycles for staff wearing protective equipment;

- providing mental health assets specific to chemical casualties and PPE utilization;
- instituting waste recovery plans for decontamination operations; and
- coordinating with supported and supporting agencies.

Postattack, or recovery, measures consist of

- practicing medical team recovery and staff technical decontamination;
- monitoring for chemical contamination;
- continuing patient evacuation if needed;
- properly disposing of hazardous waste from patient decontamination operations;
- inventorying supplies and equipment and arranging for replacements; and
- coordinating with supported and supporting agencies.

The key for effective field management of chemical casualties is to develop a workable plan and train for the event using real equipment and realistic scenarios appropriate for the location. In reality, MTFs must assume an influx of mass casualties and develop plans to effectively stabilize patients at smaller facilities and then promptly evacuate them to larger facilities with greater resources. Proper preparation for mass casualty events will ensure a smaller number of serious casualties through successful management.

Casualties may sustain additional conventional injuries; for example, blast injuries may occur when an explosive device is used to disseminate the chemical agent. The following key objectives, which also relate to military HHS and FHP, should be the focus of any field management process:

- Minimize chemical agent injuries.
- Prevent aggravation of conventional injuries during care and decontamination.
- Control the spread of chemical contamination through decontamination.
- Continue with the primary mission of caring for patients not involved with the release.

### Personnel Requirements

The process of field management can be personnel intensive, requiring between 12 and 50 workers to operate triage areas, emergency treatment areas, and decontamination lines. Personnel requirements depend on a variety of the following factors: ambient temperature in which field management operations are taking place, number of casualties, type of chemical

agent, level of fitness of medical and decontamination personnel wearing PPE, and decontamination equipment used.

### Temperature

A critical factor in the ability to sustain decontamination operations is temperature, ambient temperature, and, most importantly, wet-bulb globe temperature (WBGT). The WBGT is a composite temperature used to estimate the effect of temperature, humidity, and solar radiation on humans. It is used by industrial hygienists, athletes, and the military to determine appropriate exposure levels to high temperatures. The WBGT index combines air temperature, humidity, air flow, and radiant heat data to provide a measure for the risk of heat stress. Typically WBGT readings are below simple thermometer readings. For example, a 78.9° F (26.1° C) WBGT could roughly be equivalent to an outdoor temperature of 95° F (35° C) in the sun or 98° F (36.7° C) in the shade.<sup>34</sup> WBGT measures both radiant and evaporative temperatures. A variety of WBGT devices can be purchased. Most units are lightweight, easily transportable, and have digital displays. An example of a WBGT is shown in Figure 14-5.

Wearing protective ensemble increases the WBGT index by 10° F (5.6° C).<sup>34,33</sup> Body armor (a possible requirement for the military, but not normally for civilian medical personnel) increases the index by another 5° F (2.8° C).<sup>34,33</sup> Protective clothing increases the heat load on an individual because sweat from the skin is unable to contact air and dissipate heat through evaporation. The risk of dehydration, heat cramps, heat stroke, and other heat-induced injuries is greatly increased by the hot encapsulating protective gear, and water consumption wearing a protective mask is cumbersome, if not impossible. Many civilian protective masks lack an oral rehydration tube.

A safety monitor should be appointed to prevent injury, especially heat-related injury, for teams wearing PPEs.<sup>27</sup> Handheld heat stress calculators are commercially available to assist in calculating the time that individuals should remain in PPE.<sup>35,36</sup> Both OSHA and the military joint manual covering patient decontamination emphasize the importance of preventing heat injury. OSHA recommends periodically taking the blood pressure of workers wearing protective gear or measuring core body temperature; both are difficult to accomplish while the worker remains adequately encapsulated in protective ensemble in a contaminated, or potentially contaminated, area.<sup>27</sup> The military incorporates a program of work–rest cycles based on the WBGT index reading (Table 14-2). During the rest cycle, team members wearing PPE rest in a shaded area



**Fig. 14-5.** An example of a wet-bulb globe thermometer (WBGT).

Photograph: Courtesy of US Army Medical Research Institute for Chemical Defense, Chemical Casualty Care Division, Aberdeen Proving Ground, Md.

and drink water. Masks that allow team members to drink without mask removal should be used. Hydration units, such as Camelbaks (Camelbak, Petaluma, Calif), can be worn under hooded masks and suits.

### **Casualty Number and Agent Characteristics**

Current technology to thoroughly decontaminate patients is linear in design, and critical narrowing point “bottlenecks” are inevitable as patients are processed through a decontamination line. To reduce congestion, more decontamination lanes are added, which requires more personnel. Larger numbers of casualties also require more medical personnel to provide adequate care. Other novel ideas to hasten decontamination, particularly in a civilian setting, are to distribute personal decontamination solutions to casualties, allowing them to decontaminate themselves and others, as is done by military service members conducting immediate decontamination on the battlefield. The

aim is to readily reduce the amount of contaminant on those exposed until a more thorough decontamination can be performed.

The type of agent encountered dictates the immediate hazard to life and limb as well as the level of decontamination necessary before a patient can enter an MTF. Many people believe that all patients exposed, or potentially exposed, to a chemical agent must be thoroughly washed. Ideally, if it does not delay life saving medical care, a comprehensive shower with warm water and soap (liquid castile soap or baby shampoo) should be performed if time and circumstances permit. Situations where clothing removal alone might suffice include (a) exposure to vapor only, when agent is trapped in clothing and hair but is not on the skin; (b) cold weather situations when individuals are wearing thick clothing and the ambient temperature is 35°F (1.6°C) or below, creating a significant risk of freezing, or even below 65°F (18.3°C), when hypothermia is a greater possibility in injured people, especially if warm water is not available. In these cases the individual should be moved promptly to a warm area for a more thorough wash after clothing removal, or decontamination should be provided for exposed skin areas only.<sup>37,38</sup> An appreciation of these facts and knowledge of agent characteristics listed in Table 14-3 are critical for medical and decontamination personnel.

### **Fitness Level**

Workers who are not physically fit will fatigue faster and require more periods of rest. They may also be more prone to musculoskeletal injury. The medical management of chemical casualties can be very labor-intensive when patient lifts and litter carries are performed, especially while patient handlers are wearing PPEs or when no special ergonomic equipment (eg, roller systems, wheeled litter carriers) is available. Those who do not have adequate muscle strength will quickly fatigue after the movement of only a few litter patients. Moderate and heavy work, as is done by medical and decontamination workers, dramatically increases the strain on the cardiovascular system, and individuals who are not physically fit are at a greater risk for cardiovascular events. Those who are more physically fit will be able to wear their protective ensembles longer while incurring less cardiopulmonary risk. Personnel who are fit have enhanced pulmonary function compared to those who are less fit, allowing better oxygen exchange during exertion in protective masks. Personnel who have suffered heat stroke in the past are likely to be more susceptible to recurrence. OSHA mandates that all individuals designated to wear personal protective gear receive

**TABLE 14-2**  
**WORK-REST CYCLES AND WATER CONSUMPTION (WITHOUT PROTECTIVE ENSEMBLE)\***

Heat Category	WBGT Index (°F)	Easy Work		Moderate Work		Hard Work	
		Work-Rest (Min)	Water Intake (Qt/h)	Work-Rest (Min)	Water Intake (Qt/h)	Work-Rest (Min)	Water Intake (Qt/h)
1 (White)	78–81.9	NL	½	NL	¾	40–20	¾
2 (Green)	82–84.9	NL	½	50–10	¾	30–30	1
3 (Yellow)	85–87.9	NL	¾	40–20	¾	30–30	1
4 (Red)	88–89.9	NL	¾	30–30	¾	20–40	1
5 (Black)	> 90	50–10	1	20–40	1	10–50	1

\*Notes:

Wearing protective overgarments adds 10° F (5.6° C) to the WBGT index, and wearing body armor increases this by another 5° F (2.8° C). The work-rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hours of work in the specified heat category.

Hourly fluid intake should not exceed 1 quart and daily fluid intake should not exceed 12 quarts.

Rest means minimal physical activity while sitting or standing, accomplished in the shade if possible.

NL: No limit to work time per hour

Qt: quart

WBGT: wet-bulb globe temperature

Data sources: (1) US Departments of the Army, Marine Corps, Navy, and Air Force. *Health Service Support in a Nuclear, Biological, and Chemical Environment*. Draft. Washington, DC: DoD; 2004. FM 4-02.7, MCRP 4-11.1F, NTTP 4-02.7, AFTTP (I) 3-2.47. (2) US Department of the Army. *Health Service Support in a Nuclear, Biological, and Chemical Environment. Tactics, Techniques, and Procedures*. Washington, DC: Headquarters, DA; 2002. FM 4-02.7.

an occupational health assessment, which usually includes basic pulmonary function testing for respirator utilization and determination of their physical ability to complete assigned duties while wearing protective ensemble.<sup>27</sup>

### Decontamination Equipment

The equipment used for patient decontamination ranges from simple hoses, buckets, and sponges, to quickly erected “pop-up” decontamination tents (Figure 14-6) with intrinsic showers, to permanent decontamination systems built into hospitals. Typically, simply equipped decontamination stations are more labor intensive because water buckets and patient litters require frequent lifting. Pop-up decontamination tents and permanent hospital decontamination facilities that incorporate roller systems and integrated plumbing for litter patient decontamination help conserve energy, speed the process, and potentially reduce musculoskeletal injury in personnel. North Atlantic Treaty Organization litter carriers (Figure 14-7), or wheeled gurneys that can be decontaminated, reduce the frequency of patient lifting; sharp, long-handled seat belt cutters (Figure 14-8) reduce the repetitive opening and closing of scissors for cutting patient garments. These and other ergonomic adaptations help reduce worker strain

and subsequent risk of musculoskeletal injury. Some enclosed systems, such as pop-up tents, are frequently heated, but rarely air-conditioned. These environments in warm climates, if not air-conditioned, can become heat intense for personnel, which will necessitate more frequent work-rest cycles.

### Necessary Medical Equipment and Supplies

Critical to the emergency care of chemical casualties are adequate supplies of life saving medications for individuals exposed to rapidly lethal chemicals such as nerve agents and cyanide. Initial antidotes for nerve agents are carried by all military members, in the form of three Mark I kits (Meridian Medical Technologies Inc, Bristol, Tenn; kits contain atropine and 2-pyridine aldoxime methyl chloride) and diazepam, when there is a threat of an enemy using chemical agents.<sup>4</sup> Military medics, corpsmen, and EMTs typically carry more of these items. Most civilians, of course, do not carry these items with them, but civilian emergency responders should have adequate supplies immediately available. Emergency airway supplies are also critical for the management of chemical casualties because most chemical agent deaths are caused by respiratory compromise. Chemical monitors can be used at decontamination stations to check for the presence of

**TABLE 14-3**  
**MINIMAL DECONTAMINATION PROCEDURES BASED ON AGENT CHARACTERISTICS**

Agent Characteristics	Suggested Minimal Decontamination Procedure Before Admission To MTF
Vapors	Remove all clothing and equipment to reduce vapor trapped in cloth fibers. Wash or briskly brush hair, if exposed. Wash skin areas that were exposed to the vapor if time allows.
Liquid	Remove all clothing and equipment to reduce liquid and vapor hazard to medical staff. Decontaminate areas where liquid agent is on the skin and the protective mask.
Solid	Carefully cut off (with sharp cutting tool) and roll back overgarments to contain the solid dust particles. Patient's underclothing may need to be removed in a different area, upwind, if it is covered with solid agent. If available a HEPA-filtered vacuum can be used to vacuum garments. (Some resources suggest that an insect sprayer or mister can be used to lightly mist garments with water before removal to reduce particle aerosolization prior to protective ensemble removal. To date, this concept has not been thoroughly evaluated. Caution must be used in this process because fine agent particles could be reaerosolized with a direct flow of air or water when misting the dry material, or dry chemicals could become activated with the addition of small amounts of water). Outer clothing should always be carefully removed, followed, if possible, by a thorough washing of the skin using copious amounts of water.

HEPA: high-efficiency particulate air  
 MTF: medical treatment facility

contamination on casualties when they arrive, or after the cleaning process to check for completeness of decontamination. This equipment includes the improved chemical agent monitor, its nonmilitary equivalents, and M8 paper. The improved chemical agent monitor tests for vapor coming from liquid contaminants on patients and their clothing, and M8 paper is for direct

testing of nonvolatile liquid chemical warfare agent contaminants. In decontamination systems with large quantities of soap and water available, use of these detection devices is often not warranted because of the thoroughness of the washing process. These detectors are also limited to the types of agents and the concentration levels they are designed to detect, and may not be appropriate for all TICs and toxic industrial materials.



**Fig.14-6.** Decontamination inside a plumbed tent. The roller system supports the litter or backboard. There are many types of systems available.  
 Photograph: Courtesy of US Air Force.

**Zones of Contamination**

In interagency operations, a contaminated area is divided into zones of contamination (Figure 14-9).<sup>25,39</sup> To more effectively manage the contaminated area, a variety of control lines and points are designated depending upon the level of contamination. These same areas hold true on the battlefield.

**Hot Zone**

The hot zone is the area of chemical release. Examples include a chemical munitions impact area or an area of contamination created by an accidental or intentional TIC release from a factory storage tank. The area is determined to be contaminated with chemical agents (dry solid, liquid, or vapor). This determination is usually performed through the use of chemical monitoring devices. Individuals entering this area



**Fig. 14-7.** North Atlantic Treaty Organization wheeled litter carrier. This device allows a litter to be easily handled by one or two individuals, which reduces staffing requirements and worker fatigue.  
Photograph: Courtesy of US Army Medical Research Institute for Chemical Defense, Chemical Casualty Care Division, Aberdeen Proving Ground, Md.

must be in a high level of protection, OSHA level A or B (see Chapter 17, Chemical Defense Equipment, for a description of these protective levels), at least until the agent is known, after which lower levels may be appropriate. MTFs located in this area typically cease operations, shelter in place, and do not receive patients. The exception is the military collectively protected MTF which, although initially set up in a clean area, can continue to operate for a limited amount of time if the area it is in becomes contaminated. These structures have protective, chemically resistant liners and environmental control units that filter contaminated air.

### Warm Zone

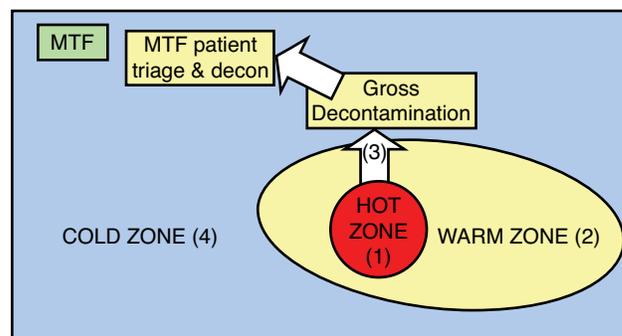
The warm zone is outside the hot zone. The level of contamination here is significantly lower than that found in the hot zone. Contamination in the warm zone is only that which is on the unprotected skin, clothing, and equipment of those entering from the hot zone. If the event was a release of chemical vapors (a gas plume or other passive release of vapors as in the Tokyo subway attack), the primary hazard is from the off-gassing of vapors trapped in patient clothing and hair. If the event is from a dry solid or liquid chemical release, then the contamination hazard would be from solids and liquids on clothing, equipment, and skin, as well as vapors coming from any liquid residue. As



**Fig. 14-8.** A variety of cutting tools are available for the rapid removal of clothing. These include (from bottom to top) the two-bladed seat belt cutter and bandage scissors.  
Photograph: Courtesy of US Army Medical Research Institute for Chemical Defense, Chemical Casualty Care Division, Aberdeen Proving Ground, Md.

noted previously, an event involving a solid or liquid hazard would require a more intense decontamination effort.

Once an MTF begins to receive patients, the area where contaminated patients are received would be designated as part of the warm area. In the warm area medical and decontamination team members



**Fig. 14-9.** Zones of contamination after a chemical release. (1) Hot zone: contaminated area of chemical release; (2) warm zone: contaminated individuals enter from the hot zone; (3): evacuation corridor: contains patient decontamination stations; (4) cold zone: area free of solid, liquid, and vapor contamination.

MTF: medical treatment facility  
Diagram: Courtesy of US Army Medical Research Institute for Chemical Defense, Chemical Casualty Care Division, Aberdeen Proving Ground, Md.

working with the contaminated patients wear an OSHA level C protective ensemble to protect them against the limited, but still dangerous, amounts of toxic materials on the patients. This area is referred to as the contamination reduction zone, decontamination zone, or protective action zone in some references.<sup>25,27,39</sup>

### **Evacuation Corridor**

The evacuation corridor, which is within the warm zone, incorporates land evacuation routes from the hot zone for casualties who may still be contaminated. Patient decontamination stations, whether located immediately outside the hot zone or near the door of a receiving MTF, are within this corridor. In some instances, particularly in a military battlefield situation, seriously injured contaminated patients who are still wearing their protective gear and have undergone only operational decontamination (see Levels of Decontamination, below) may be evacuated by rotor-wing aircraft to an MTF well outside the warm zone. In these cases a separate warm zone would be created to include the aircraft landing area and the MTF patient decontamination area.

### **Cold Zone**

Areas free of solid, liquid, and vapor contamination are in the cold zone. All military MTFs are initially established in contamination-free areas. Before being allowed into the cold zone, individuals must go through decontamination and be determined contamination-free; this requirement applies not only to patients but also to medical workers and decontamination team members in protective ensemble. Individuals in the cold zone do not need to wear any type of protective equipment, except in the event of a nosocomially transmitted biological agent such as plague (*Yersinia pestis*) or smallpox. In these cases, respiratory and contact precautions must be followed by those in contact with the patient. The cold zone may also be referred to as the postdecontamination zone, support zone, or clean zone.<sup>25,27,39</sup>

### **Levels of Decontamination**

Various stages of patient decontamination are described in the processing of a CBRN casualty.<sup>3,14,33</sup> The military uses the following three levels of decontamination (the official names for these levels may change, but the order of performance will remain the important focus).

### **Immediate**

Immediate decontamination is performed by the individual who is exposed to the hazardous agent, or provided by a buddy partner immediately after the exposure event. Military members are trained to decontaminate themselves using the M291 skin decontamination kit and M295 equipment decontamination kit or reactive skin decontamination lotion, if available, as soon as possible after exposure to a chemical agent. This is the most effective time to perform decontamination to lessen the dose on the skin and significantly reduce future medical complications.

### **Patient Operational Decontamination**

Patient operational decontamination is performed before loading a contaminated patient onto a "dirty evacuation" asset. The patient remains in a protective mask and overgarment, and any gross contamination is removed. Plastic sheeting may also be used inside the vehicle to help minimize contaminant spread during transport. This procedure would more likely be followed under operational tempos that do not allow for the removal of the patient's protective clothing until arrival at an MTF with appropriate resources to care for the individual. For example, the situation of a continued chemical threat with no replacement clothing is quite possible on the battlefield.

### **Patient Thorough Decontamination**

Patient thorough decontamination is performed at the MTF or a consolidated troop and patient decontamination area in close proximity to the incident site, if possible. Personnel remove the patients' clothing and thoroughly clean them using either soap and water or another decontaminant. The patients are then determined to be free of contamination before being brought into the MTF.

### **Military Management Concepts in the Civilian Setting**

The civilian setting is quite different from the military battlefield scenario. The civilian scenario described below would probably apply to the military in a situation in which service members were exposed to chemical agents while wearing their duty uniform, which offers no protection, such as in an unexpected terrorist attack on a military installation or the sudden release of toxic fumes from a nearby industrial accident. See Table 14-4 for a comparison of casualty care and decontamination

TABLE 14-4

## COMPARISON OF MILITARY BATTLEFIELD AND CIVILIAN CASUALTY CARE AND DECONTAMINATION

Process	Military on Chemical Battlefield	Civilian or Unprepared Military
Immediate decontamination	Immediate decontamination takes place upon contamination using M291, RSDL, or other kit.	Casualties may wash contaminated areas if knowledgeable, otherwise they must wait for HAZMAT crews and first responders
Operational patient decontamination	Contaminated patients, wearing protective gear, can be transported on designated vehicles to decontamination facilities.	Local vehicles may have to be used if available. Ambulance services may be hesitant to transport contaminated patients.
Emergency medical care	Care can begin on the battlefield. Initiated by the individual or a buddy. Unit medics can also provide lifesaving care while they are wearing protective equipment.	Medical care is delayed in all instances by minutes. Care may not be initiated until the patient is moved from the incident site and then decontaminated. Care may be initiated earlier if medical personnel are trained to provide assistance while wearing protective equipment.
Thorough patient decontamination	Performed before patient enters the MTF, whether a small or large facility. May have gross contaminants removed at a centralized facility outside the hot zone with continued decontamination at the hospital decontamination area if indicated.	Performed before patient enters the MTF, whether a small or large facility. May have gross contaminants removed at a centralized facility outside the hot zone with continued decontamination at the hospital decontamination area if indicated.

HAZMAT: hazardous materials

MTF: medical treatment facility

RSDL: reactive skin decontamination lotion

in the military and civilian setting.

The majority of civilians are not aware of the characteristics of chemical agents or the steps to take for immediate decontamination. Many, appropriately, would probably attempt immediate decontamination of a visible or symptomatic agent by washing or wiping. They might effectively perform immediate decontamination by washing with copious amounts of water from a sink or hose, or by using bottled water. Wiping could be performed using frequently carried moistened disposable baby wipes. Liquid agent could be wiped from the skin using any nontoxic absorbent material such as clean dry sand, bread, flour, or baby powder, followed by wet wipes.<sup>40</sup> If the individual does not perform any of these procedures, then decontamination may not take place until the arrival of first responders, who may be delayed. Also, civilian casualties, unlike military personnel, would not have immediate access to nerve agent antidotes (or would not know how to use them). The casualties would need to wait until treated by appropriately supplied first responders.

In the civilian sector, HAZMAT crews and fire de-

partments can take 15 minutes or longer to assess the hot zone and establish patient decontamination lanes in the warm zone<sup>23</sup>; during this time civilian casualties would remain contaminated and untreated. If the toxin is an organophosphate nerve agent, then antidotes would be provided, if available, by the civilian first responder. Under the best of situations in a civilian setting, casualty treatment is often administered only after the patient is evacuated by HAZMAT crews to the warm zone triage area. Local civilian EMTs could be trained to provide stabilizing patient care while wearing PPE in the warm zone's patient collection area before decontamination. In an optimal situation, first responder EMTs in PPE could accompany HAZMAT crews into a contaminated area and begin triage and treatment of victims as they are being evacuated.<sup>26</sup> In the military battlefield scenario, of course, initial care and decontamination is provided at the incident site, in the hot zone, before and during patient evacuation.

Patient operational decontamination would probably not be done in the civilian sector because most contract ambulance services will not take contaminated patients on their vehicles. Some semblance of operational decon-



using any available materials such as bottled water, baby wipes, or reactive skin decontamination lotion.

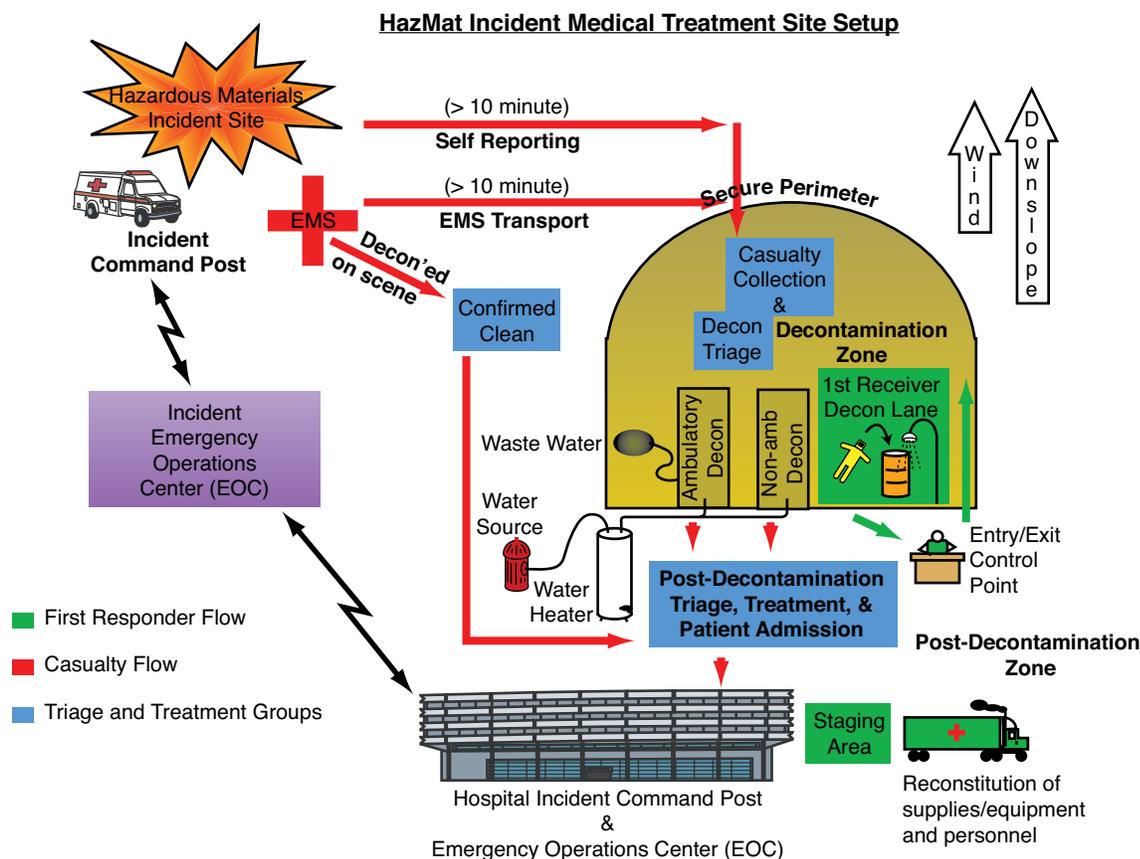
For more thorough decontamination, civilian casualties are provided with gross decontamination in the warm zone by the fire department, using fire engine water spray or water from plumbed decontamination tents (Figure 14-11), and more complete decontamination at the MTF prior to entry into the facility. For the military casualty, thorough decontamination occurs at the patient decontamination station, which is located outside the military MTF. In both the civilian and military decontamination station, a patient moves through a sequence of substations to account for valuables, remove clothing, and wash. These same stations are established whether decontamination takes place in an area with limited resources, such as an Army BAS or civilian fire department decontamination line, or a facility with more robust capabilities, such as a moderate sized or larger military or civilian hospital

(Figure 14-12). OSHA documents refer to the area outside an MTF, where contaminated patients arrive and are triaged and decontaminated, as the hospital decontamination zone.<sup>27</sup>

Once the patients are decontaminated, they move across the hot line into the hospital postdecontamination zone. Name designations for each area may differ depending on the setting, but the sequence of steps in the process is similar. The areas described below are adopted from several sources.<sup>3,7,8,14,27,33,42,43</sup>

**Entry Control Point and Arrival Area**

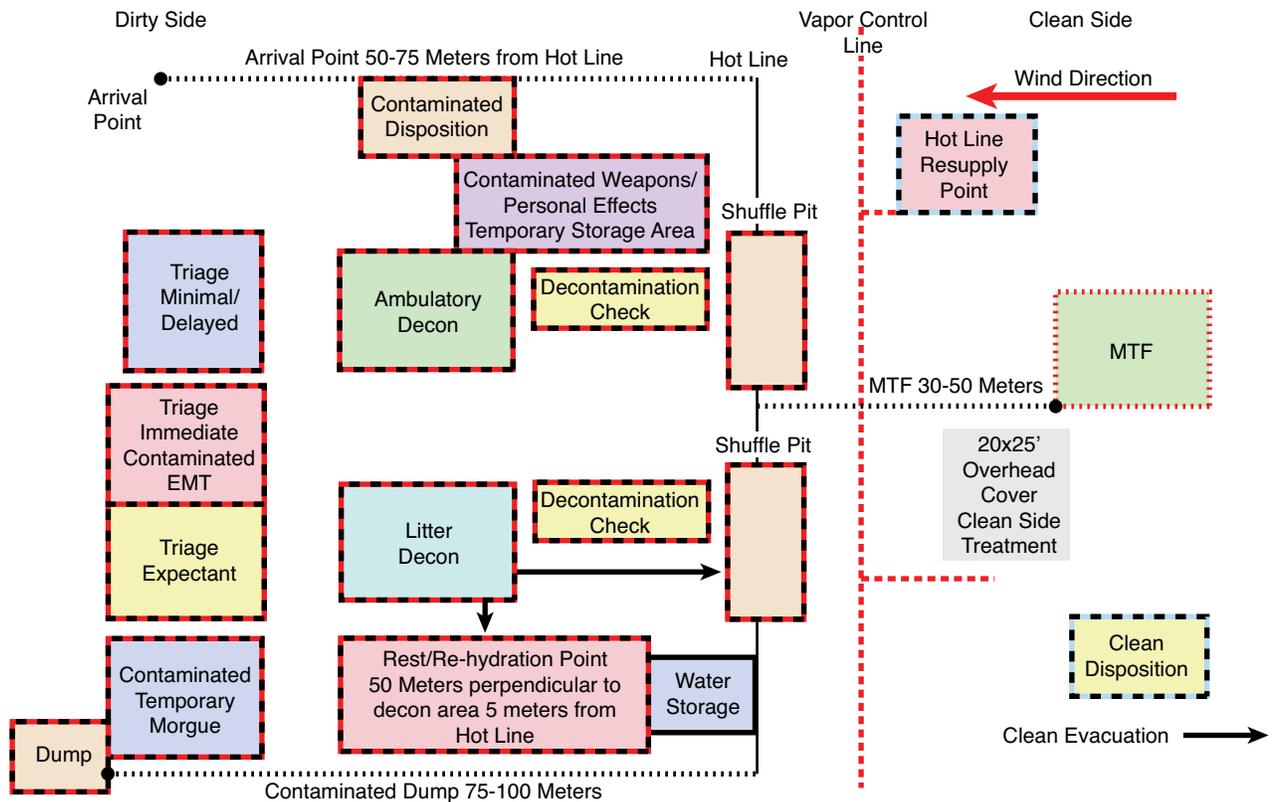
The entry control point is the doorway to the decontamination area. This entrance is typically barricaded in some way to regulate traffic flow and is usually staffed by security personnel wearing protective ensemble. Ambulances, other vehicles, and ambulatory casualties go through this control point on their way



**Fig. 14-11.** This is one example of the layout of a civilian hazardous materials incident patient decontamination area at the periphery of the hot zone or at the entrance to the medical facility. This model takes into consideration a 10-minute lag time between incident occurrence and the self-reporting of patients. It follows the same sequence of steps noted in Fig. 14-12.

EMS: emergency medical service

Diagram: Courtesy of Commander Duane Caneva, US Navy.



**Fig. 14-12.** Another, more detailed, example of the layout of a patient decontamination site at a medical treatment facility (military or civilian). Note the relative positioning of specific triage areas, the waste dump, rest/rehydration points, areas for storage of personal effects, hot line, and vapor control line.

EMT: emergency medical treatment

MTF: medical treatment facility

Diagram: Courtesy of the US Army Medical Research Institute for Chemical Defense, Chemical Casualty Care Division, Aberdeen Proving Ground, Md.

to the arrival area. On land the entry control point would be located well in front of the decontamination area, and at sea it would be at the transport aircraft or watercraft casualty loading area located on land. At the arrival area vehicles are unloaded and patients are brought to the adjacent triage area. Maintaining traffic discipline in this area is critical to ensure unimpeded flow of patients and vehicles. The arrival point on land must be large enough to accommodate ever expanding numbers of casualties; at sea the arrival point would be the aircraft or watercraft landing area. At this point monitoring devices may be used to check for contamination on patients. All personnel in these areas wear a MOPP level 4 or level C equivalent protective ensemble.

### *Triage Area (Warm Side)*

Patients are moved to the triage area from the arrival point, where a triage officer (trained physician, nurse,

EMT, physician's assistant, dentist, or veterinarian) quickly triages the patient, who is then moved to a respective immediate treatment area (also known as the warm side emergency medical treatment station). Patients are triaged according to their priority for medical treatment (immediate, delayed, minimal, or expectant); level of decontamination (high or low); and further medical evacuation required (urgent, priority, or routine). See Chapter 15, Triage of Chemical Casualties, for more detailed information. Medical workers in this area wear a level C equivalent protective ensemble.

The immediate treatment area should be located near the entrance to the litter decontamination lanes to allow direct access for patients who will be litterborne. Expectant patients are located adjacent to the dirty side emergency treatment station, but farther away from the litter decontamination lanes, so that these patients can be retriaged and stabilized for decontamination when the dirty side no longer has

patients. The delayed treatment area is located near the entrances of both the litter and ambulatory patient decontamination lanes; delayed patients can be processed through either lane when available. Finally, the minimal patient triage treatment area should be positioned nearer to the ambulatory decontamination lane because these patients can walk through the lane with minimal assistance. In the military, minimal patients are typically sent back to their units after receiving medical care without needing to be decontaminated or crossing to the clean side, where the MTF is located. In the civilian sector, the movement of these patients should not interfere with the processing of more serious casualties through the decontamination line.

The warm side emergency treatment station (or immediate patient treatment area) is where life saving care is provided to stabilize the patient for decontamination or transport. Care given at this station includes the administration of antidotes, quick decontamination of contaminated skin areas, intubation, and intravenous administration of fluids. Medical staff in this area are trained in these procedures and capable of performing them while wearing OSHA level C protective ensemble.

### *Decontamination Area*

Lanes are established in the decontamination area for litter and ambulatory patients. The number of staff required for a decontamination team is dictated, as discussed earlier, by ambient and WBGT temperature in the field management operations area, number of casualties, type of chemical agent, level of fitness of personnel wearing protective ensemble, and decontamination equipment used. Minimum staffing levels are two decontamination workers per litter patient, who must have their clothing cut off, and one per ambulatory patient, who can undress and decontaminate themselves under supervision. If only one or two patients need decontamination, it can be done with a garden hose, buckets and sponges, or built-in shower. Larger numbers of casualties require more efficient decontamination procedures. More specific suggestions for personnel are found in Chapter 16, Decontamination of Chemical Casualties.

In the Army and Navy (in support of USMC units), decontamination is carried out by nonmedical personnel from the supported military units who are supervised by medical personnel. In Air Force and some Navy shipboard decontamination teams, all the team members come from the medical unit. These personnel wear OSHA level C PPE or the military equivalent. If their garments are not completely water resistant, they also wear water repellent toxicological agent protective

aprons to keep the protective overgarments dry and allow for apron decontamination before performing patient lifts.

The decontamination process usually takes up to 10 to 20 minutes for a litter patient and 5 to 10 minutes for an ambulatory patient, depending on the type of decontamination equipment and the team training level. Plumbed equipment that dispenses soap and water and roller systems for litter patients are more efficient than the more labor-intensive processes using minimal equipment such as buckets and sponges.

A final check for thoroughness of contamination is often incorporated at the end of the decontamination process. This check is more critical when water-conservative methods, such as washing with buckets and sponges, are used. In these situations, some areas of the skin might remain incompletely washed. Decontamination equipment that incorporates a large volume but a low-pressure flow of water provides a more thorough wash and can reduce the necessity for a final check. Warm water, and warm decontamination areas, are more likely to ensure thorough patient compliance and minimize the development of patient hypothermia.

### *Hot Line*

The hot line is located at the end of the decontamination line, before the clean area. At this point, all liquid contamination has been removed from patients and decontamination team (it is sometimes referred to as the liquid control line). Patients are typically nude at this point, and decontamination station workers have removed their protective overgarments. In the civilian sector, patients undergoing gross decontamination by a fire department might still have on their undergarments. If clean covering garments are available, victims should be strongly encouraged to doff their wet undergarments, which could hold agent, particularly if exposed to liquid or potent aerosol. Patients entering an MTF should be nude but covered by a hospital gown, to insure that contamination does not enter the facility and allow for patient privacy.

### *Vapor Control Line*

The vapor control line delineates the location where no vapor hazard remains from clothing that has been removed in the decontamination area. Although not required for biological and radiological contamination, this line is critical for chemical contamination. The vapor control line is approximately 10 feet beyond the hot line as the patient proceeds toward the clean side. In the military, the air in this area may be monitored by a stationary vapor monitor such as the automatic chemical agent detector alarm.

### *Triage and Treatment Area (Clean Side)*

The triage and treatment area (clean side) is part of the cold zone, located near the vapor control line (OSHA refers to this area as the hospital post-decontamination zone). The recently decontaminated patients are retriaged in this area, and wait for processing into an ambulance, if this occurs at a decontamination station separate from an MTF, or to await movement into an MTF from an adjacent decontamination station.

### *Additional Areas*

Other areas that may be necessary, but not in all situations, include the following:

- contaminated waste dump to store contaminated waste until proper removal;
- fresh and waste water bladders if decontamination tent systems are used;

- warm side disposition areas used by the military, where casualties in protective gear have been provided operational decontamination and await dirty evacuation;
- a warm side temporary morgue for storage of the contaminated remains of those who die during field management;
- a warm side weapons and contaminated personal effects storage area for storage and eventual disposition of patient items;
- litter decontamination area for military decontamination operations with minimal equipment;
- a warm side rest area for decontamination crews and medical team members;
- a clean side supply point where medical and decontamination supplies can be apportioned as necessary; and
- a clean side disposition area for staging decontaminated patients for transport to another location.

## SUMMARY

Field management of chemical casualties involves ongoing triage, treatment, and patient movement through the medical system to obtain the most appropriate care available given the situation and resources. Conducting field management in a chemically contaminated environment requires that medical and decontamination personnel wear the equivalent of OSHA level C protective ensemble for protection from contaminants on patients and hazardous vapors emitted by the contaminants.

The military's immediate medical response to a chemical event on the battlefield is identical across the services, using self and buddy aid. This response differs from the civilian response, because of lack of training in self-decontamination and treatment and lack of readily available resources. Unprotected military personnel (without PPE and individual decontaminants or antidotes) exposed to a chemical release would encounter some of the same challenges as the civilian population.

Civilian casualties unable to flee the scene of a chemical release must wait until HAZMAT teams and fire departments arrive on the scene. This initial response typically takes 10 minutes or longer, and victims may not encounter a medical care provider for 30 minutes or more after their initial exposure. Typically medical treatment is not provided until after the victim has

undergone decontamination. This process is changing for civilian medical responders, particularly in larger metropolitan communities; many fire department medical responders wearing PPE are now prepared to provide early life saving medical triage and care to contaminated casualties before decontamination. This alignment of civilian and military medical response should improve response capabilities and patient outcomes in the event of a mass casualty incident.

Although the positioning of up-front medical care in the warm zone may differ, the process of patient decontamination is similar for civilian and military. It includes the following: accounting for patient valuables, clothing removal, washing, and movement across the hot line; evidence recognition and proper chain of custody procedures; recognition of secondary explosive devices; clean side triage and treatment; and patient disposition from the decontamination site. The procedures may vary slightly depending on the decontamination platform (land vs sea) and type of equipment used (eg, buckets and sponges vs robust plumbed systems or designated permanent decontamination facilities). Decontamination typically takes from 5 to 20 minutes, depending on the medical condition of the casualty, the type of decontamination equipment, and the level of training of the decontamination team.

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