

UC Irvine

UC Irvine Previously Published Works

Title

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Permalink

<https://escholarship.org/uc/item/6t59b2mh>

Journal

American Journal of Emergency Medicine, 26(1)

Author

Koenig, Kristi L, MD

Publication Date

2008

Peer reviewed

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Abstract

Since the U.S. terrorist attacks of September 11th, 2001, concern regarding use of chemical, biological, or radiological weapons is heightened. Many victims of such an attack would present directly to healthcare facilities without first undergoing field decontamination. This article reviews basic tenets and recommendations for healthcare facility-based decontamination, including regulatory concerns, types of contaminants, comprehensive decontamination procedures (including crowd control, triage, removal of contaminated garments, cleaning of body contaminants, and management of contaminated materials and equipment), and a discussion of methods to achieve preparedness.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

1. Introduction

Decontamination of persons exposed to chemical, biological, or radiological materials has historically fallen within the purview of community-based hazardous materials response teams, such as fire department hazmat teams. Additionally, federal resources exist to assist in decontamination of patients following radiological emergencies. However, recent events have shown that many victims of chemical exposures use healthcare facilities as their first point of contact, bypassing community resources.¹⁻⁵ Victims of biological and radiological exposures may also present first to healthcare facilities. Healthcare facilities can no longer assume that they will not need to primarily decontaminate large numbers of victims exposed to chemical, biological, or radiological materials.

Current recommendations and guidelines for decontamination have traditionally focused on one of three areas: decontamination and treatment for a specific agent, determining when decontamination can be considered sufficiently complete, and prehospital decontamination. Few papers have specifically discussed healthcare facility-based decontamination.⁴⁻⁸ In this work, we synthesize the most recent data and focus on current issues and recommendations for healthcare facility decontamination. The recommendations are divided into the categories of regulatory concerns, contaminants, and decontamination procedures. Additionally, reasonable expectations for healthcare facilities preparedness are discussed.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

2. Scope of the Problem

Decontamination is the process of removing or neutralizing hazardous agents on people or equipment. Removal of hazardous agents on skin is important for the following reasons:

- To prevent or diminish further absorption and subsequent toxicity. Many substances disrupt the integrity of the skin, and become systemic toxins following absorption or allow opportunistic infection by naturally occurring pathogens.
- To prevent or diminish contamination of other persons or equipment with substances on the victim's clothes or skin (*secondary contamination*).
- To prevent the closure of portions of a facility, e.g., the emergency department (ED) or other areas where contaminated victims may enter.

Distinction will not be made between chemical agents developed by the military and other chemical agents found in the community. Terrorists may use agents in the community since these agents may be available and poorly secured; the distinction between victims of an accidental spill and deliberate release is academic and may not be known for days after the event. These recommendations discuss essential decontamination needs for facilities that can provide stabilization of victims contaminated with hazardous agents, who are brought to or self-report to the facility.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

This neither implies that all facilities must provide all aspects of decontamination, nor that facilities are limited to providing only the critical interventions cited in this paper.

There is an acknowledged difference between accepting and working within each facility's limitations and planning for such limitations. These recommendations discuss planning that is appropriate before a disaster. This paper will not address existing facility hazardous agent management programs for hazardous stores on site, terrorist acts committed against the facility itself, or facility security issues.

3. Regulatory Concerns

Regulatory issues regarding decontamination devolve from the Joint Commission and the Occupational Safety and Health Administration (OSHA). Both require hospitals to protect workers. OSHA does not address victim decontamination, and the Joint Commission requires a plan coordinated with the local community, but does not provide specifics. In fact, the Joint Commission emphasizes all-hazard planning and has limited requirements aimed specifically at decontamination. The major requirement is found in Joint Commission's Environment of Care Standard (EC) 1.4 which states that, "The [emergency management] plan ... identifies facilities for radioactive, biological, and chemical isolation and decontamination."⁹ OSHA states, "Medical personnel who will decontaminate victims must be trained to the First Responder Operations Level with emphasis on the use of personal protective equipment (PPE) and decontamination procedures. The employer must certify that

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

personnel are trained to safely perform their job duties and responsibilities. This includes a minimum of 8 hours of training or demonstrated competencies and an annual refresher [education].”¹⁰ Further, OSHA mandates that employers will provide a safe work environment; decontamination of victims is an important component of maintaining employee health.

The probability of treating contaminated patients is an essential component of an informed response plan based on known risk and historical events. In most facilities, the likelihood of an event requiring decontamination is generally low, but the potential impact of such an event is high (low probability, high impact event). Private hospitals are required to participate in community disaster planning for hazardous materials incidents according to SARA Title III (Superfund Amendments and Reauthorization Act of 1986). Although little is known concerning the likelihood or extent of contamination from a terrorist event, there is anecdotal evidence that supports the likelihood that contaminated victims will present themselves or be transported for care without decontamination. At the Tokyo subway event in 1995 involving the release of sarin vapor, healthcare workers at a medical center were exposed to victims and became ill from secondary exposure.^{1, 2, 11} In 2005, an industrial chemical spill in Indiana resulted in symptomatic exposures to hospital staff as a consequence of vapors trapped in victims’ clothing.³

Conflict may arise between a facility’s desire to remain free of contamination, and federal statute under the Consolidated Omnibus Budget Reconciliation Act of 1986 (also known as the Emergency Medical Treatment and Active Labor Act, or 42 USC

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

1395dd) requiring the facility to medically screen and stabilize all victims presenting to the facility.¹² Although decontamination is not required if the hospital is not equipped to perform this function, as with any other specialized medical service, this does not obviate the responsibility to provide screening and stabilizing care under COBRA/EMTALA. Recent discussions have begun to address EMTALA concerns at a disaster response system level, rather than at an individual patient care level. However, at the time of this publication, no specific guidelines have been published by the Centers for Medicare and Medicaid Services to address disaster-related EMTALA concerns. The authors are not aware of any EMTALA-related formal complaints filed as a consequence of recent disasters.

4. Contaminants

A wide range of chemical, biological, and radiological agents exist which could be deliberately used or unintentionally released, leading to a decontamination event at a healthcare facility. Although it is useful to be familiar with common threats, particularly the most likely agents to be found in each local community as identified by mandatory hazards vulnerability analyses, it is more useful to be familiar with general concepts and broadly applicable methods for decontamination such that appropriate preparations can be made and decontamination begun promptly when indicated, even before the specific identity of the chemical agent is known. Subsequent identification of a specific agent may allow the healthcare facility to refine the decontamination processes.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Chemical agents that might be used by terrorists range from warfare agents to toxic chemicals commonly used in industry. Criteria for determining priority chemical agents include:

- Chemical agents already known to be used as weaponry
- Availability of chemical agents to potential terrorists
- Chemical agents likely to cause major morbidity or mortality
- Potential of agents for causing public concern and social disruption
- Agents that require special actions for public health preparedness

A broad selection of specific chemical agents might be of consequence in the emergency healthcare setting (Table One). Although the presentation, decontamination, and treatment of exposure to each agent is beyond the scope of this review, excellent resources exist which can be quickly accessed upon identification of a specific agent. Recommended sources include the “Decontamination” chapter of Medical Aspects of Biological and Chemical Warfare (available online at http://www.bordeninstitute.army.mil/cwbw/default_index.htm), the Material Safety Data Sheet for an individual agent (available online at various locations or physical locations near the agent as specified by law), and the Centers for Disease Control and Prevention Chemical Agents Emergency Preparedness and Response list (available online at <http://www.bt.cdc.gov/agent/agentlistchem.asp>).^{13, 14} In general, chemical agents have the potential for rapid spread and immediate damage to patients and decontamination personnel. Chemically contaminated patients are more likely to present en masse, in extremis, and with external evidence (odor, visible contamination)

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

of contamination.² In addition to the general decontamination procedures discussed below, extra attention should be paid to agent identification if time and personnel availability permit; identification of specific chemical agents has greater potential for changing or focusing decontamination management than specific identification of other agents.¹⁴

Biological contaminants could range from accidental releases of biohazardous wastes to intentional exposures with bioweapons. In many cases of terrorism, the biological attack may be covert and go unrecognized for days, in which case decontamination may not be an issue (the anthrax letter attacks being a notable exception). Six biological agents are considered Category A agents by the CDC based on their ease of dissemination or transmission, high mortality rates, and potential for major public health impact and social disruption:

- Anthrax
- Botulism
- Plague
- Smallpox
- Tularemia
- Viral hemorrhagic fevers

Overall, biological agents are more likely to be familiar to clinicians than chemical or radiological agents. Additionally, decontamination is less likely to be an issue than infection control.¹⁴⁻¹⁶ With few exceptions, patients known to be contaminated with biological agents are unlikely to require advanced decontamination techniques beyond

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

“strip and shower”.¹⁷ It is quite plausible that biological contamination may go unnoticed until the patient is already infected or affected by toxin. Patients may be more likely to present individually or in small groups over a short time course after exposure, rather than en masse after a single well-defined time point.¹⁸

Radiological contamination may have several sources.¹⁹ An explosive device with incorporated radiological materials (also called a radiologic dispersal device [RDD] or “dirty bomb”) has been the subject of much recent speculation. Other possible sources include accidental release from a nuclear generating station or medical radiation facility, misuse or failure of an industrial radiation source, or a nuclear detonation. Each source presents different challenges for decontamination. For example, radioisotopes produce three different types of radiation with different penetration properties (alpha, beta, and gamma); familiarity with the irradiating source and route of exposure (e.g., ingestion, dermal, inhalation) may allow the clinician to more rapidly assess a victim’s potential for significant radiation exposure.²⁰

Victims of radiological exposure may be divided into two general categories: patients exposed to radiation but not contaminated with radioactive material, and patients with actual radioisotope contamination. The first category (exposed but not contaminated), by definition, do not require decontamination. Further, these patients, while requiring specific and often aggressive medical management, do not represent a radiation hazard to other patients or to healthcare providers.

The second category, victims with direct radiological contamination, may begin decontamination with the general measures described below. These patients are likely

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

to be more easily identified than biologically contaminated patients; intentional releases of radioactive material in the form of a radiologic dispersal device are accompanied by a noticeable explosion (with subsequent traumatic injuries far outweighing the danger from the likely minimal radiation exposures), while unintentional releases are most likely in industrial scenarios where workers and supervisors are aware of the potential for radiological contamination.¹⁹ Of note, nuclear devices present explosive and radiation hazards, but present a lesser risk of significant, immediate radiological contamination; with the exception of small, tactical nuclear devices, the range within which radioactive material can quickly be deposited is subsumed by the range in which thermal and blast energy would be lethal. Therefore, survivors of a nuclear detonation are less likely to be contaminated with radiological materials. However, nuclear fallout can be detected even within the first day after a nuclear detonation, and can contain highly active radiological materials, making the distinction between RDDs and nuclear devices less useful.²¹

5. Decontamination Procedures

Contamination is affected by four primary factors: contact time, concentration, temperature, and the physical state of the contaminant. The goal of decontamination is to counteract these factors.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

- **Contact time:** The longer a contaminant is in contact with an object, the greater the probability and extent of permeation into that object. For this reason, minimizing contact time is one of the most important objectives of a decontamination program.
- **Concentration:** Molecules flow from areas of high concentration to areas of low concentration. As concentrations of chemicals increase, the potential for permeation of personal protective clothing increases.
- **Temperature:** An increase in temperature generally increases the permeation rate of contaminants.
- **Physical state of chemicals:** As a rule, gases, vapors, and low-viscosity liquids tend to permeate more readily than high-viscosity liquids or solids.

Decontamination can be divided into 5 steps: crowd control, triage, removal of contaminated garments, cleaning of contaminant from the body, and management of contaminated materials and equipment.

5.1. Crowd Control and Communications: Potentially contaminated individuals should be moved through a corridor to either the decontamination area or an overflow area if the main decontamination area is at capacity.

Communications and coordination with local emergency personnel and facility hazardous materials (Hazmat) teams will allow for improved preparation and use of decontamination materials for arriving victims. The communication network should

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

include both community (e.g., integration into the community disaster response system and citation in the local emergency management plan) and national contacts (e.g., from national toxic substance response centers and the U.S. Federal Departments of Transportation, Energy, and Health and Human Services). Adequate communications and coordination may be a major factor in whether an emergency plan performs well.

5.2.Triage: Identify the contaminant, the degree of contamination, and level of victim distress. If the contaminant cannot be readily identified, look for toxidromes (constellations of signs and symptoms consistent with a specific exposure) to attempt to identify the class of agent. Contaminated victims should not enter the hospital. Communication with the incident commander is critical.

Determine who needs to be decontaminated. Consider and weigh the need for decontamination based on the symptoms, known contact, or presence of an agent. If the agent is known – what are the characteristics of the agent? What are the chances of secondary contamination? Was decontamination accomplished prior to ambulance transport or self-presentation, and was it adequate?

Triage allows for the determination of the degree of contamination, potential for secondary contamination, level of distress of the victim, and assignment of victim decontamination protocols and treatment interventions. Contamination indicators include smell, sight, information from victims, bystanders, or relatives, public announcements via television or radio, notification by public health or emergency medical services, and product information (e.g., Material Safety Data Sheets).

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Detectors are available to alert emergency personnel to the presence of contaminating agents; however, while some are fairly sensitive (such as radiation detectors), most (particularly biological agent detectors) suffer from poor sensitivity and specificity.

Triage personnel are responsible for working with the decontamination team to adjust decontamination procedures if necessary.

Surveillance is necessary before, during, and after decontamination. There is no single highly sensitive direct reading instrument available for the wide range of chemical or biological contaminants that may be encountered. If the facility incident commander or individual responsible for decontamination does not know the identity of the contaminant(s), this individual can attempt identification via one of the following methods:

- Refer to placards, labels, bills of lading, waybills, wheel reports, and Material Safety Data Sheets
- Ask owner, site specialist, employee or victims
- Contact the shipper
- Contact the manufacturer
- Call the Chemical Transportation Emergency Center CHEMTREC at (800) 262-8200, and provide them with as much information as possible including train or truck number and/or the manufacturer's name

The choice of medical procedures performed in the decontamination area must be made based on the individual scenario. Emergency resuscitation should be provided if

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

clinically indicated and resources permit. Any item used in the decontamination area or vehicle used to transport contaminated victims should be considered contaminated until it has been thoroughly cleaned. A radiological survey meter can detect the presence of, though not the type of, residual radioactive materials. Routine diagnostic procedures should be postponed until the victim is moved out of the decontamination area. Some published radiation protocols recommend long lists of supplies be maintained in the decontamination area. This should not be problematic if the decontamination area is in or adjacent to the Emergency Department (ED), where all necessary supplies should be readily available and can be monitored for expiration dates. If this is not logistically feasible, it may be necessary to use a runner to obtain needed items.

Most exposures to biological agents can be managed using universal infection control precautions (standard precautions) for healthcare staff, and do not require particular victim decontamination techniques beyond soap and water. Exposure to mycotoxins would call for procedures similar to those used for chemical agents, including extensive victim decontamination; the use of an alkaline hypochlorite solution may be beneficial.²²

5.3. Removal of Contaminated Garments: The removal of contaminated garments is the first step in decontamination. Removing all clothes will remove 70-85% of the contaminants.²³ Removed garments should be contained, and disposal procedures should comply with those used for other hazardous materials. Additionally, law enforcement personnel may require access to removed garments as part of evidence

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

collection in case of a terrorist or other criminal action; accordingly, if time permits, removed garments should be placed in containers which are individually marked with the victim's name, and retained until otherwise directed by law enforcement authorities.

5.4. Cleaning of Contaminant from the Body: The type of decontamination procedure used will depend on the situation. Most decontamination can be accomplished by simple high-volume dilution with water. Occasionally, mild soaps will be required to remove oily or greasy substances. Promoting victim self-decontamination will significantly decrease the required number of staff for the decontamination process.

Ambulatory victims should be encouraged to self-decontaminate.²³ If a person is already contaminated, consideration should be given to that person assisting non-ambulatory victims. Victims should be directed to proceed to a decontamination area. It has been suggested that ventilation fans should be strategically placed to direct airflow away from the facility; however, their use is unproven, and there are theoretical concerns regarding hypothermia and spread of contamination.

After removal of garments, the contaminant must be cleaned from the body. This is a time-sensitive issue. Procedures are designed to prevent washing contaminants from affected to unaffected areas. Abrasive cleaning should be avoided, as it can cause microscopic abrasions which could enhance contaminant uptake into the body. Options include water, water with an additive, specific-acting decontaminants, foam, dry agents, and cream.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Currently, tepid water is the material of choice for victims. Although less effective than some decontaminants (e.g., it does not work well on oily/viscous materials such as polychlorinated biphenyls, a contaminant often encountered by firefighters), it is less risky than using chemical solutions. When water is used, it should be applied to dilute a liquid contaminant on victims following removal of the victim's clothes and should be removed by rinsing with soapy water. If the contaminant is a powder, remove clothes first, as to not spread it more by wetting.

A number of additives, such as emulsified solvents or chlorine (< 0.5%) have been suggested.²² The advantage of additives is that they improve decontamination when the contaminant is known. The disadvantage is the potential of the additive to cause further damage to the skin or accelerate the absorption of the contaminant.

These mixtures include:

- 5% sodium carbonate and 5% trisodium phosphate – for inorganic acids and metal processing wastes, such as the heavy metals mercury, lead, and cadmium
- 0.5% sodium hypochlorite (bleach solution) – may be mixed from household bleach or 10% calcium hypochlorite ampules (as found in military decontamination kits). For use in decontaminating non-body cavity wounds or contaminated items not on personnel.
- 5% trisodium phosphate – for pesticides, fungicides, chlorinated phenols, dioxins, cyanides, ammonia, and other non-acidic inorganic waste

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

- Dilute hydrochloric acid. One pint of concentrated hydrochloric acid into 10 gallons of water, mixed with wooden or plastic spoon – for inorganic bases, alkali and caustic wastes
- Concentrated powdered detergent and water. Mix into paste and gently apply with brush
- Soap solution in a paste form - for radioactive materials and biological agents

Chlorine solution, such as sodium hypochlorite or chlorine bleach, may be instilled into non-body cavity wounds and then removed by suction to an appropriate disposal container. Within about five minutes, this contaminated solution will be neutralized and become non-hazardous. Subsequent irrigation with saline or other surgical solutions should be performed. Prevent the chlorine solution from being sprayed into the eyes, as corneal opacities may result.²²

Decontaminants that are effective only against a certain group of substances can be a superior alternative to generally effective decontaminants if they have a faster and better effect against the substance in question or are better tolerated by the victim. Examples of such substances are chloramine solutions. These have good effect against mustard agent and V-agents (e.g., VX, VR) but are ineffective against nerve agents of the G-type (e.g., sarin, soman, tabun). A sodium bicarbonate solution rapidly renders nerve agents of the G-type harmless; but when used in connection with V-agents, it produces a final product almost as toxic as the original substance. This does not prevent V-agents from being washed-off with a soda solution, provided a sufficient

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

amount is used. However, the final product will always be poisonous. The disadvantage of specifically-acting decontaminants is two-fold: one must know which chemical warfare agent has been used, and access to several different types of decontaminating substances is required.

At the time of this report, decontamination foam manufacturers have applied to FDA to allow for the use of the foam in decontaminating victims. These foams typically contain a mixture of chemicals such as hydrogen peroxide, quaternary ammonium compounds, and chloride/hypochlorous compounds.²⁴ However, foam has currently only been approved for use on equipment. The Sandia National Laboratories has test data that indicates an advantage to using foam, and a number of organizations use it. Foam can render biological agents (e.g., anthrax spores) and chemicals inert, whereas water does not.²⁴

In some cases, a dry method may give a better result in decontaminating deeply penetrated agents than a wet method. A dry powder such as Bentonite or “Fuller’s Earth” is useful for decontamination of thickened agents since it bakes together the sticky substance, making it easier to remove. Fuller’s Earth is a fine-grained, naturally occurring earthy substance that has a substantial ability to adsorb impurities or coloring bodies from fats, grease, or oils. Fuller’s Earth consists chiefly of hydrated aluminum silicates that contain metal ions such as magnesium, sodium, and calcium within their structure; this compound is commonly used in Israel.

Some dusts may react with water, so if such a substance is suspected or if radioactive particles are involved, forceps and vacuuming should be used to remove the

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

contaminants. There are a small number of agents that react to water, so dry decontamination should be available. Water should be avoided in the presence of metallic sodium, potassium, lithium, cesium, and rubidium, because these will react on contact with water. Dusts of pure magnesium, white phosphorus, sulfur, strontium, titanium, uranium, yttrium, zinc, and zirconium will ignite on contact with air. If these substances are suspected, any residual metal should be removed with forceps and stored in a container of mineral oil. If radioactive particles are on or embedded in the skin, these should be removed by forceps and disposed of by the radiation safety officer.

There are individual decontaminants which can simultaneously function as a protective cream and be used prophylactically. Canada has developed a mixture of a reactive oxime and its potassium salt in polyethylene glycol, which has both these properties. This mixture, Reactive Skin Decontamination Lotion (RSDL) is an active, broad spectrum, viscous liquid chemical weapon decontamination agent which is designed for use by individuals and medical personnel in decontamination. RSDL is self-indicating as to reactivity - turning clear from its characteristic transparent yellow color if the reactive agent is totally consumed - and indicating that additional RSDL should be applied to the area.

Freezing the area using ice water has been suggested, but is not well-documented. This method could adversely affect the victim by inducing hypothermia and skin structure injury, and is not recommended at this time.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Dialogue on processes to assess decontamination effectiveness (“how clean is clean?”) is ongoing, and warrants continued attention by the scientific and response communities. A comprehensive review of this complex issue was addressed in a study by the Oak Ridge National Laboratory for the Department of Energy.²⁵ The study suggests that post-decontamination cleanliness is subjective and lacks scientific input. Study recommendations include establishment of national databases to capture and share decontamination information, inclusion of the issue on public health and medical agendas, and public education on prevention and reduction of potential agent exposure.

5.5. Management of Contaminated Materials and Equipment: Plans must be in place for the management of contaminated materials and equipment. These plans should account for materials inadvertently brought by victims (e.g., on clothes and vehicles). In addition to water, consideration should be given to the use of foam in order to reduce the quantity of water runoff. Decontamination foam can be used for equipment and has the advantage of rendering biological agents inert. Rooms in fixed spaces are best decontaminated with gases or liquids in aerosol form (e.g., formaldehyde).

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

6. Preparatory Concerns

Certain key issues should be addressed as part of a facility decontamination program. These include risk review, victim reception and management, triage, surveillance, decontamination procedures and materials, runoff control, isolation, staffing, training, and risk communications.

Risk review of known hazardous agents used by the facility and those present in the community has the potential of improving decontamination material selection and use. (Hazards vulnerability analyses are required under the Joint Commission Environment of Care / Emergency Management standard 1.4.)

A victim receipt and management plan that addresses the entry of victims must be designed for the individual facility (e.g., single building versus campus). The objective is to move contaminated victims and equipment (e.g., taxicabs) through a controlled corridor. This all-hazards plan can be delineated into levels that allow a facility's incident command structure to effectively manage specific events, regardless of their size or complexity. The site entry plan should allow for arrivals with either advance notification or no prior notification; often, the least injured will present first with no warning. This plan should also control staff, preventing movement through contaminated areas and potential spread of the contaminant to other locations. Entry and exit points to exposed areas should be conspicuously marked.

Pre-arranged decontamination areas consist of fixed decontamination units, mobile trailers, tents or constructed facilities, or a combination of these modalities. The

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

advantages of a fixed decontamination area are that it is in place and ready to be used for time-sensitive decontamination, does not require significant amounts of staff to set up or disassemble equipment, and does not require storage. A major disadvantage is that the structure takes up space, and its location therefore becomes an issue. If located adjacent to the emergency department, it could distract from the facility's appearance and hinder daily operations. If located out of sight, it could be difficult to access. The decontamination area would be used for those victims who have been severely contaminated or contaminated with an unknown agent.

Mobile trailers have the advantage of having all necessary equipment located in one place and in a well-designed configuration. Disadvantages are that the trailer must be stored somewhere, the trailer must be retrieved and driven (by someone that can pull a trailer) to the site of use, there must be an area that can accommodate the trailer, and staff must be available around-the-clock to retrieve the trailer, set up the decontamination system, and disassemble it when the mission is completed.

Advantages of tents or constructed facilities are that they are inexpensive and can be erected in various locations. Disadvantages are lack of durability, the need to store equipment where staff can rapidly access it, the need for around-the-clock available staff to construct the site, and vulnerability to wind and other weather.

An individual facility may select a combination of the approaches cited above. For example, there may be showers permanently fixed to the ceiling structure of an open-air parking garage or side of a building.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Staff requirements should be included in the victim receipt and management plans. The number of staff required and recommended for each shift, including weekends, holidays, and leave, should be determined. Mandatory personnel functions are listed in Table 2. Frequently, facilities may choose to have non-medical personnel provide a substantial portion of the decontamination procedures (e.g., removal of garments and washing of victims) while reserving medical personnel for triage and treatment functions as well as monitoring of personnel. In some cases, union or other contractual obligations may limit which staff members are available for decontamination duties.

The physical security of each facility needs to be reviewed because victims and family may act irrationally. For instance, those attempting unauthorized entry or willing to use force to ensure treatment of friends and relatives may endanger the facility and staff.

Victims need to be decontaminated prior to entering the facility service areas to prevent disruption of ongoing activities. Also, healthcare providers, with their patient-focused mindset, may be inclined to render aid and perhaps compromise their own safety.

Training should be provided to decontamination personnel that includes visual identification of contaminant physical properties, assessment using monitoring equipment, and technical assessment of the effect of decontamination procedures on the contaminant following its removal. Staff must be monitored during victim

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

decontamination to ensure that they are not suffering from adverse effects of personal protective equipment or secondary contamination.²⁶

An arranged decontamination area is a specialized area selected by the facility to handle a victim that has extensive contamination or where the contaminating agent is unknown. This area can accommodate a limited number of victims, and is therefore often not appropriate for mass decontamination. Ventilation of the decontamination area should be performed by dedicated equipment separated from the facility's ventilation system. Priority should be given to decontamination of the eyes, mucous membranes, and severely affected areas of skin. No definitive guidance is in place to direct the appropriate length of time required for decontamination. It should be expected that non-ambulatory patients will require additional time, as will patients requiring stabilizing medical treatment. Some experts recommend limiting treatment to basic life support measures and life-saving procedures within the decontamination area; this decision will depend upon the facility's capabilities as well as the number and level of severity of victims. All unprotected equipment should remain in the area until decontaminated; staff should wear disposable outer garments. After decontamination, the victim can be moved into the general treatment area and treated as any other victim.

Irrespective of the type of decontamination area selected, there is always the potential for the number of victims to exceed capacity, particularly in the setting of a mass casualty event such as a radiologic dispersal device explosion or a transportation systems chemical attack.^{1, 2} In many communities, healthcare facility-based

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

decontamination is most likely to occur in mass casualty events, as smaller events may be completely contained and controlled by the community hazardous materials team. An overflow decontamination area would allow for placement of victims arriving at the facility in excess of usual capacity. In the overflow area, victims that may have been exposed to a contaminant should remove their clothing, place it in sealed containers or bags, place valuables in marked containers, and be provided privacy garments. A flexible water source is needed for non-ambulatory victims. Options for site selection and establishment of the overflow area should be determined by the facility as part of disaster preparation. An open area, such as a parking lot or lawn, may be appropriate, with consideration given to varying weather conditions and availability of water and electrical power. An auditorium, covered parking area, or other large internal facility may be needed in case of inclement weather. If the area is internal, ventilation should be separate from the facility. Covered parking lots may have fixed waterlines and connections to hang curtains. A secondary equipment overflow area should also be available for contaminated equipment, such as transport vehicles and emergency equipment.

The facility should establish a team to handle contaminated victims who bypass the decontamination area or overflow area and arrive (contaminated) at the facility. The purpose of the decontamination team is to assess the situation, limit contamination of the facility, and expedite victim removal, decontamination, and care. The team should direct contaminated victims to exit through the same portal they entered or through the closest exit, reducing spread of contamination. Victims should be escorted to the

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

designated decontamination area and not through the hospital. Emergency showers are generally found throughout facilities, and their use may be advantageous. The facility should be locked down and secured, reducing the potential for further contamination. If the contaminant is chemical, the contaminated area should remain closed until cleared by the hazmat team. The facility hazmat team should be separate from the decontamination team; they will determine whether anyone may have been contaminated and will take appropriate actions. Team members need protective equipment and portable communication equipment.²⁶

Foam decontamination requires additional equipment, but produces less water waste. Support for water decontamination is listed in Table 3. Runoff will occur when water is used. Ideally, this should be collected and not allowed to enter storm drains. Determine where the closest sewer collection and storm drain system entry points are located. If water cannot be contained, it is preferred that it goes into the sewer system instead of the storm drain. However, in a mass casualty situation, either is acceptable; the Environmental Protection Agency (EPA) exempts facilities from retaining wastewater in emergency situations where lives are at risk.^{27, 28} Discussion with local emergency planning authorities in advance of a decontamination event is prudent. Contaminated wash and rinse solutions should be contained by using catch basins or trench pits lined with plastic. Spent solutions should be packaged and labeled for disposal with other substances involved at the incident. In some cases decontamination solutions may pose no hazard and can be disposed of on-site. Use caution to prevent the contaminant from being tracked off-site into private vehicles. All

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

materials and equipment that are disposed of must be documented. Contaminated materials must not leave the decontamination area until decontaminated.

Victims exposed to certain biological agents may require quarantine; if symptomatic following exposure, they may require isolation.²⁹ The Centers for Disease Control and Prevention is a resource for assisting state and local health agencies in developing policies and procedures for investigating unusual events and unexplained illnesses.

All personnel, including subcontractors and visitors, entering the exclusion zone or decontamination area must have appropriate medical monitoring in accordance with OSHA's Hazardous Waste Operations and Emergency Response Standards (HAZWOPER, 29 CFR 1910.120).

These standards also apply to training. Individuals who develop decontamination procedures and select PPE for workers who help decontaminate victims must be trained to the First Responder Operations Level with additional training in decontamination procedures. Such individuals do not need the lengthy specialized training required to be certified hazardous materials technicians. Any personnel involved in victim decontamination must be trained a minimum of 8 hours in accordance with OSHA's HAZWOPER standard, on topics needed to address their roles and functions, the zones in which they work, and the likelihood that they will encounter contaminated patients. Ancillary personnel expected to clean the decontamination area must be trained in accordance with 29 CFR 1910.120(q)(11). They must have access to Material Safety Data Sheets for those chemicals that may be used to decontaminate equipment and areas. Coordination with community resources for clean-up assistance

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

should be included in contingency plans. Training must be provided on recognizing contaminated victims.

7. Summary Recommendations

In summary, removal of clothing coupled with tepid water and mild soap (“strip and shower”) for victims and staff is the safest and most effective decontamination approach. Several other materials are available and may be used as a substitute for or in conjunction with water to improve effectiveness when the contaminant is known. Dry decontaminants may be used prior to water, if the contaminant is oily or tacky. Foam for decontaminating equipment and other materials may be useful in reducing water runoff. Foam has been purchased by the military but is currently approved only for equipment decontamination, not for victim treatment. Cream decontaminant is available in Canada and has the advantage of reducing the risk of spreading a contaminant to non-contaminated parts of the body. More than one decontaminating material may be appropriate. The effectiveness of any decontamination method must be assessed when the first patient presents and periodically throughout the decontamination process. Few data exist that provide valid measures to assess successful decontamination, particularly when there are mass numbers of contaminated victims.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

8. Conclusions

Although on-scene decontamination of victims exposed to chemical, biological, or radiological materials is the preferred scenario following such an exposure, healthcare facilities must be prepared to manage contaminated patients. Regulatory issues surrounding the question of facility-based decontamination remain unresolved, but it is clear that healthcare workers who could reasonably be expected to provide decontamination services must undergo OSHA approved training. Victims may be exposed to a wide range of agents; rapid identification is preferable, but general decontamination measures may need to be instituted prior to agent recognition. With some important exceptions, most agents can be removed from victims through removal of clothing and subsequent washing with soap and tepid water. Planning for decontamination events must be made at facility-specific levels, and must include a community-wide program with involvement of regional leaders familiar with the specific hazards a facility is most likely to face. Finally, facility and personal security, as well as personnel health, must be protected through appropriate planning and use of approved personal protective equipment.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

References

1. Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 2: Hospital response. *Acad Emerg Med*. Jun 1998;5(6):618-624.
2. Okumura T, Takasu N, Ishimatsu S, et al. Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med*. Aug 1996;28(2):129-135.
3. Nearly 30 Workers Recovering After Chemical Spill. *WLKY News*, 2005.
4. Auf der Heide E. Disaster planning, Part II. Disaster problems, issues, and challenges identified in the research literature. *Emerg Med Clin N Am*. May 1996;14(2):453-480.
5. Auf der Heide E. The importance of evidence-based disaster planning. *Ann Emerg Med*. Jan 2006;47(1):34-49.
6. Boatright CJ, Koenig KL. The Emergency Management Strategic Healthcare Group Technical Advisory Committee: Expert guidance for complex issues. *Veterans Health System Journal*. June-July 2001;6(5):27-32.
7. Koenig KL. VA Capability to Enhance the Medical Response to a Domestic Biological Threat. Paper presented at: Institute of Medicine Forum on Biological Threats and Terrorism: How Prepared Are We? Assessing the Science and our Response Capabilities, 2002.
8. Macintyre AG, Christopher GW, Eitzen E, Jr., et al. Weapons of mass destruction events with contaminated casualties: effective planning for health care facilities. *JAMA*. Jan 12 2000;283(2):242-249.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

9. Emergency Management Standards - EC.1.4 and EC.2.9.1.
<http://www.jcrinc.com/subscribers/perspectives.asp?durki=2914&site=10&return=289>.
10. Hazardous Waste Operations and Emergency Response. *U.S. Department of Labor, Occupational Safety and Health Administration Standards*. Vol 29 CFR Part 1910.120; 1998.
11. Kulling P. The Terrorist Attack With Sarin in Tokyo on 20th March 1995. 8 November 1998; <http://www.sos.se/SOS/PUBL/REFERENG/9803020E.htm>. Accessed 20 April, 2006.
12. Emergency Medical Treatment and Active Labor Act. Vol 42 USC 1395; 1986.
13. Chemical Agents Emergency Preparedness and Response.
<http://www.bt.cdc.gov/Agent/agentlistchem.asp>. Accessed 10 November, 2006.
14. Hurst CG. Decontamination. In: Zajtchuk R, Bellamy RF, Sidell FR, Takafuji ET, Franz DR, eds. *Medical Aspects of Chemical and Biological Warfare*. Washington, DC: Office of the Surgeon General, Department of the Army, USA; 1997:351-360.
15. Schultz CH, Koenig KL. Weapons of Mass Destruction. In: Marx JA, Hockberger RS, Walls RM, eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice*. 6th ed. Philadelphia: Mosby Elsevier; 2006.
16. Schultz CH, Mothershead JL, Field M. Bioterrorism Preparedness I: the Emergency Department and Hospital. In: Darling RG, Mothershead JL,

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

- Waeckerle JF, Eitzen EM, eds. *Bioterrorism. Emerg Med Clin N Am.* Vol 20(2); 2002:437-455.
17. Koenig KL. Strip and shower: the duck and cover for the 21st century. *Ann Emerg Med.* Sep 2003;42(3):391-394.
 18. Koenig KL, Kahn CA, Schultz CH. Medical strategies to handle mass casualties from the use of biological weapons. *Clin Lab Med.* 2006;26:313-327.
 19. Koenig KL, Goans RE, Hatchett RJ, et al. Medical treatment of radiological casualties: current concepts. *Ann Emerg Med.* Jun 2005;45(6):643-652.
 20. Dodds P. Britain Tracing Poison That Killed Spy. *Associated Press.* 28 November, 2006.
 21. Alt LA, Forcino CD, Walker RI. Nuclear Events and Their Consequences. In: Zajtchuk R, ed. *Medical Consequences of Nuclear Warfare.* Washington, DC: Office of the Surgeon General, Department of the Army, USA; 1989:1-16.
 22. Darling RG, Woods JB, Dembek ZF, et al., eds. *USAMRIID's Medical Management of Biological Casualties Handbook.* 5th ed. Fort Detrick, Frederick, Maryland: U.S. Army Medical Research Institute of Infectious Diseases; 2004.
 23. Koenig KL. Strip and shower: the duck and cover for the 21st century. *Ann Emerg Med.* Sep 2003;42(3):391-394.
 24. Rogers JV, Richter WR, Choi YW, et al. Technology Evaluation Report: Evaluation of Spray-Applied Sporicidal Decontamination Technologies. National Homeland Security Research Center, U.S. Environmental Protection Agency; EPA 600/R-06/146; 2006.

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

25. Muller Vogt B, Sorensen JH. How Clean is Safe? Improving the Effectiveness of Decontamination of Structures and People Following Chemical and Biological Incidents. Oak Ridge National Laboratory, U.S. Department of Energy; ORNL/TM-2002/178; 2002.
26. Koenig KL, Boatright CJ, Hancock JA, et al. Health Care Facilities' "War on Terrorism": A Deliberate Process for Recommending Personal Protective Equipment. *Am J Emerg Med.* Feb 2007;25(2):185-95.
27. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). *US Code.* Vol 42 USC 103; 1986.
28. Environmental Protection Agency Alert Bulletin: First responders' environmental liability due to mass decontamination runoff: Office of Solid Waste and Emergency Response, Environmental Protection Agency; 2000.
29. Laws and Regulations: Isolation and Quarantine Fact Sheet.
<http://www.cdc.gov/ncidod/dg/isolationquarantine.htm>. Accessed 12 June, 2007.

Table Legends:

Table 1: Categories of Chemical Agents

Table 2: Recommended Personnel Functions Within a Victim Receipt and Management Plan

Table 3: Support for Water Decontamination

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Table 1: Categories of Chemical Agents

Nerve agents

Tabun (GA)	Ethyl N,N-dimethylphosphoramidocyanidate
Sarin (GB)	Isopropyl methylphosphanofluoridate
Soman (GD)	Pinacolyl methylphosphanofluoridate
GF	cyclohexylmethylphosphanofluoridate
VX	o-ethyl-[S]-[2-diisopropylaminoethyl]-methylphosphonothiolate

Blood agents

Hydrogen cyanide
Cyanogen chloride

Blister agents

Lewisite
An aliphatic arsenic compound, 2-chlorovinylchloroarsine

Nitrogen and sulfur
mustards

Phosgene oxime

Heavy metals

Arsenic
Lead

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

	Mercury	
Volatile toxins		
	Benzene	
	Chloroform	
	Trihalomethanes	
Pulmonary agents		
	Phosgene	
	Chlorine	
	Vinyl chloride	
Incapacitating agents		
	BZ	3-quinuclidinyl benzilate
	Agent 15	
Pesticides, persistent and non-persistent		
Dioxins, furans, and polychlorinated biphenyls (PCBs)		
Explosive nitro compounds and oxidizers		
	Ammonium nitrate	

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

mixed with fuel oil

Flammable industrial

gas and liquids

Gasoline

Propane

Poisonous industrial

gases, liquids, and

solids

Cyanides

Nitriles

Corrosive industrial

acids and bases

Nitric acid

Sulfuric acid

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Table 2: Recommended Personnel Functions Within a Victim Receipt and Management Plan

- o Incident commander
- o Group to set-up and provide supplies to the decontamination team and supervise clean-up and disposition of contaminated items
- o Group to greet contaminated victim(s) – communication coordinator
- o Triage leader – sort contaminated victims
- o Employee to rinse victims, if necessary
- o Employee to assist victim remove clothes and bag valuables, if necessary
- o Employee to assist in drying off/dressing/admitting victim
- o Employee to clear decontaminated victims and staff for exit from decontamination area
- o Crowd control
- o Safety officer with technical control over decontamination
- o Treatment – emergency physicians, ED nurses and aides, other support personnel such as respiratory therapists, security, and maintenance personnel
- o Other individuals may also be involved indirectly, such as the finance officer

Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials

Kristi L. Koenig, MD, FACEP, Connie J. Boatright MSN, RN, John a. Hancock MS, CSP, Frank J. Denny, David S. Teeter PharmD, RPh, Christopher A. Kahn MD, MPH, Carl Schultz MD, FACEP

Table 3: Support for Water Decontamination

- o Water source, showers, hose, collection pools, and a means of collecting the water in the pools, or a mechanism to collect runoff water from drains
- o Heating and cooling units as appropriate (water and air)
- o Cleaning supplies (mild soap), disposable sponges/towels (soft)
- o Scissors
- o Towels for drying
- o Visqueen drop cloth
- o Fans (after consideration of theoretical concerns)
- o Means of collecting belongings and ID bands (labels and pens, sealable plastic bags, paper bags)
- o Modesty garments (gowns, blankets, screen or rope-blankets, trash bags)
- o Instructions in multiple languages (laminated)
- o Personal protective equipment (PPE) may be reduced to a lower level following the decontamination procedure but cannot be discontinued until cleared by the individual having technical control over decontamination
- o Set up and tear down equipment
- o Contain, manage and dispose of waste