

Chapter 7

DECONTAMINATION

Overview

Decontamination is the reduction or removal of hazardous agents. Decontamination of chemical agents may be accomplished by removal of the agents by physical means or by chemical neutralization or detoxification. Patient decontamination is personnel, time, and equipment intensive. Personnel and equipment requirements, although also important, are discussed in other publications and will not be included here. Please refer to USAMRICD's *Field Management of Chemical Casualties Handbook* (the "gold book"; 4th ed, 2014). There are three levels of patient decontamination:

- 1. Immediate decontamination.** Primarily performed to protect the individual. Here the contaminated person removes contamination from his or her individual protective equipment (IPE), other equipment, and the skin as quickly as possible after exposure. If the casualty is unable to self-decontaminate, another individual (buddy) provides immediate decontamination.
- 2. Patient operational decontamination.** Performed to protect operators of transport vehicles. Unit members remove as much contamination as possible from the casualty's IPE, equipment, and skin, without removing the IPE. This is done to prepare the individual for transport on designated "dirty" evacuation assets to the next level of medical care.
- 3. Patient thorough decontamination.** Operators of the patient decontamination station perform this level of decontamination to protect medical facility staff and equipment and to reduce patient contamination. It involves removal of contaminated IPE and a thorough decontamination of any contaminated

skin before the patient enters a medical treatment facility (MTF). The decontamination area should be located about 50 meters downwind from the treatment area (ie, the wind must be blowing from the clean treatment area to the dirty decontamination area).

Prompt removal of an agent from the skin by any nontoxic means is the key to patient decontamination. Immediate decontamination by the soldier can mean the difference between minor and significant medical effects from agent exposure.

The Decontamination Process

Decontamination is the process of removing or reducing a hazardous agent, whether chemical, biological, or radiological, from a person or object. Chemical contamination can present as a vapor, aerosol, liquid, or dry solid. The key reference for patient decontamination in the military is US Army Field Manual 4-02.7, *Health Service Support in a Nuclear, Biological, or Chemical Environment*.

Decontamination is not as critical for those contaminated only by vapor exposure, because vapor will continue to volatilize in the open air; rapidly brushing the hair if vapor is trapped in it and removing a patient's clothing where vapors can be trapped will usually remove the vapor hazard. Exposures to aerosols, liquid, and dry solids will require more thorough decontamination if a patient is to enter a facility where staff are not in protective clothing.

The most important level of decontamination to minimize injury to the patient is immediate decontamination, because it reduces the patient's exposure to a toxic agent. It is most effective if performed within 1 or 2 minutes after exposure, particularly with HD, but the dose will still be reduced to some degree if decontamination is performed later. The goal is to remove the agent from the skin with whatever means are available that are not toxic or abrasive to the skin.

Decontamination studies have been conducted using common household products for the purpose of identifying decontaminants for civilians as well as field expedients for

soldiers. Timely use of water, soap and water, or flour, followed by wet tissue wipes, produced results equal, nearly equal, and in some instances better than those produced by the use of Fuller's earth, Dutch powder, and other compounds. (Fuller's earth and Dutch powder are decontamination agents currently fielded by some European countries.) These results were expected because (1) no topical decontaminant has ever shown efficacy with penetrated agent, (2) agents in large enough quantity, especially vesicants, may begin penetrating the skin before complete reactive decontamination (detoxification) takes place, and (3) early physical removal is the most important part of decontamination.

Copious amounts of water or soap and water are effective for washing away most agents. A high volume of water under low pressure should be used, combined with wiping the skin. Fat-based soaps should be used rather than detergents. The fat-based soaps, such as castile soap or other mild liquid soaps, help to emulsify thickened agents such as VX and HD.

Physical removal is imperative because *none* of the chemical means of destroying these agents do so instantaneously. While decontamination preparations such as fresh hypochlorite react rapidly with some agents (eg, the half time for destruction of VX by hypochlorite at a pH of 10 is 1.5 minutes), the half times of destruction for other agents, such as mustard, are much longer. If a large amount of agent is present initially, a longer time is needed to completely neutralize the agent to a harmless substance.

Methods

Three methods of skin decontamination are preferred in the military:

1. Reactive Skin Decontamination Lotion (RSDL) is a new decontaminant that replaced M291 skin decontamination kit. RSDL is a packaged sponge containing a liquid solution that effectively wipes away chemical agents and simultaneously provides oxime protection against nerve agents. It is used on intact skin, but not in open wounds or eyes. RSDL is small and easily carried by service members, making it well suited for field use. Decontamination of the casualty using RSDL does

- not eliminate the need for decontamination at a field facility.
2. Soap and water is a low-cost decontaminant that removes agents by washing them off the skin. It is effective for removing chemical, biological, and radiological contaminants. It does not destroy biological agents or neutralize radioactive particles. Both fresh water and sea water have the capacity to remove chemical agents not only through mechanical force but also via slow hydrolysis; however, the generally low solubility and slow rate of diffusion of chemical warfare agents in water significantly limit the hydrolysis rate. The predominant effect of water and water/soap solutions is the physical removal or dilution of agents, although slow hydrolysis does occur, particularly with alkaline soaps. Fat-based liquid soaps (eg, baby shampoo, castile liquid soap, or soft soap) attract and help emulsify chemical agent so that the action of the water can wash it away. Detergents that can dry the skin should not be used. Clean water can be used to irrigate wounds; only copious amounts of water, normal saline, or eye solutions are recommended for the eye.
 3. A 0.5% hypochlorite solution with an alkaline pH is an alternate skin decontaminant that can be used when the others are not available and water is limited. It is a solution of nine parts water to one part bleach (which at this dilution is not harmful to the skin). The solution is wiped on the skin and can be rinsed off several minutes later with fresh water. The solution causes a chemical decontamination reaction involving very slow oxidative chlorination and hydrolysis. The term "oxidative chlorination" covers active chlorine chemicals such as hypochlorite. Hypochlorite solutions act universally against the organophosphorus and mustard agents. Both VX and HD contain sulfur atoms that are readily subject to oxidation and hydrolysis. The decontamination effectiveness of these solutions increases as the hypochlorite pH levels go above 8, but these levels are harmful to the skin. Therefore, at the dilution level of 0.5%, the oxidation and hydrolysis effects are present but very limited. Hypochlorite should not be used in abdominal wounds or open chest wounds, on nervous tissue, or in the eye. Irrigation of the abdomen may lead to adhesions and is therefore also contraindicated. The use of hypochlorite

in the thoracic cavity may be less of a problem, but the hazard is still unknown.

Certification of Decontamination

Certification of decontamination for chemical agents is accomplished by any of the following: processing through the decontamination station, M8 paper, the Joint Chemical Agent Detector (JCAD), or the Improved Chemical Agent Monitor (ICAM). If proper procedure is followed, the possibility of admitting a contaminated casualty to an MTF is extremely small.

Wound Decontamination

The initial management of a casualty contaminated by chemical agents requires removal of IPE and skin decontamination before treatment at an MTF. When thorough decontamination is performed, contaminated bandages are removed and wounds are flushed with sterile water. Any contaminated debris (such as clothing in the wound that may hold agent) is irrigated and removed from the wound by decontaminated gloved hands, instruments, or another no-touch technique. The bandages are then replaced only if bleeding recurs or the wound needs protection from further contamination. Contaminated tourniquets are replaced with clean tourniquets and the sites of the original tourniquets decontaminated. Splints are thoroughly decontaminated by rinsing with a 0.5% hypochlorite solution or copious amounts of soap and water, but should only be removed by a physician or a medic directly supervised by a physician.

General Considerations

Of the agents discussed, only two types, vesicants and nerve agents, may present a hazard from wound contamination. Cyanide is quite volatile, so it is extremely unlikely that liquid cyanide will remain in a wound, and it requires a very large amount of liquid cyanide to produce vapor adequate to cause effects.

Mustard converts to a cyclic compound within minutes of absorption into a biological milieu, and the compound rapidly (within minutes) reacts with components of the wound: blood,

necrotic tissue, and the remaining viable tissue. If the amount of bleeding and tissue damage is small, mustard rapidly enters the surrounding viable tissue, where it will quickly biotransform and attach to tissue components. Its biological behavior will be much like an intramuscular absorption of the agent.

Although nerve agents cause toxic effects by their very rapid attachment to the enzyme acetylcholinesterase, they also quickly react with other enzymes and tissue components. As with mustard, the blood and necrotic tissue of the wound will buffer nerve agents. Nerve agent that reaches viable tissue will be rapidly absorbed, and since the toxicity of nerve agents is quite high (a lethal amount is a small drop), it is unlikely that casualties who have had much nerve agent in a wound will survive to reach medical care. Potential risk to the surgeon from possibly contaminated wounds arises from agent on foreign bodies in the wound and from thickened agents.

Thickened Agent

Thickened agents are chemical agents that have been mixed with another substance (commonly an acrylate) to increase their persistency. They do not dissolve as quickly in biological fluids, nor are they absorbed by tissue as rapidly as other agents. Similarly, VX, although not a thickened agent, is absorbed less quickly and may persist in the wound longer than other nerve agents.

Casualties with thickened nerve agents in wounds are unlikely to survive. Thickened HD has delayed systemic toxicity and can persist in wounds even when any large fragments of cloth have been removed. Though the vapor hazard to surgical personnel is extremely low, contact hazard from thickened agents does remain and precautions should always be taken.

No country is currently known to stockpile thickened agents. In a chemical attack, the intelligence and chemical staffs should be able to identify thickened agents and alert medical personnel of their use.

Off-Gassing

The risk from vapor off-gassing from chemically contaminated shrapnel and cloth in wounds is very low and not significant.

Furthermore, there is no vapor release from contaminated wounds without foreign bodies. Off-gassing from a wound during surgical exploration will be negligible (or zero). No eye injury will result from off-gassing from any of the agents. A chemical-protective mask is not required for surgical personnel.

Foreign Material

The contamination of wounds with mustard or nerve agents is largely confined to the foreign material (eg, uniform and protective garment in the wound). The removal of this cloth from the wound effectively eliminates the hazard. There is little chemical risk associated with individual fibers left in the wound. No further decontamination of the wound for chemical agent is necessary.

Wound Exploration and Debridement

During exploration and debridement, surgeons and their assistants are advised to wear a pair of well-fitting (thin), butyl rubber gloves or double latex surgical gloves and to change them often until they are certain there are no foreign bodies or thickened agents in the wound. This is especially important where puncture is likely because of the presence of bone spicules or metal fragments.

The wound should be explored with surgical instruments rather than with fingers. Pieces of cloth and associated debris must be quickly disposed of in a container of 5% hypochlorite. The wound can then be checked with the ICAM, which may direct the surgeon to further retained material. It takes about 30 seconds to get a stable reading from the ICAM; a rapid pass over the wound will not detect remaining contamination. The wound is debrided and excised according to the usual procedures, maintaining a no-touch technique. Removed fragments of tissue are placed into hypochlorite. Tissue such as an amputated limb should be placed in a sealable, chemical-proof plastic or rubber bag.

Hypochlorite solution (0.5%) may be instilled into noncavity wounds following the removal of contaminated cloth. This solution should be removed by suction. Within 5 minutes, this

contaminated solution will be neutralized and nonhazardous. Subsequent irrigation with saline or other surgical solutions should be performed.

Surgical practices should be effective for the majority of wounds in identifying and removing the focus of remaining agent within the peritoneum. Saline, hydrogen peroxide, or other irrigating solutions may not decontaminate agents, but may dislodge material for recovery by aspiration. The irrigation solution should not be swabbed out manually with surgical sponges. The risk to patients and medical attendants is minuscule; however, safe practice suggests that any irrigation solution should be considered potentially contaminated. Following aspiration by suction, the suction apparatus and the solution should be disposed of in a solution of 5% hypochlorite.

Superficial wounds should be thoroughly wiped with soap and water or a 0.5% hypochlorite solution and subsequent irrigation with normal saline.

Instruments that have become contaminated should be placed in 5% hypochlorite for 10 minutes prior to normal cleansing and sterilization. Reusable linen should be checked with the ICAM or M8 paper for contamination; if found to be contaminated, it should be disposed of in a 5% to 10% hypochlorite solution.

Conclusion

Decontamination at the MTF is directed toward (1) eliminating agent transfer to the patient during removal of protective clothing, (2) decontaminating or containing contaminated clothing and personal equipment, and (3) maintaining an uncontaminated MTF. Current doctrine specifies the use of RSDL, soap and water, or a 0.5% hypochlorite solution. These decontaminants have been tested and found to be effective when used appropriately.