

COMPREHENSIVE REVIEW

Disaster Preparedness: Hospital Decontamination and the Pediatric Patient—Guidelines for Hospitals and Emergency Planners

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Abbreviations:

EMS = emergency medical services
PAPR = powered air purifying respirators
PPE = personal protective equipment

Abstract

In recent years, attention has been given to disaster preparedness for first responders and first receivers (hospitals). One such focus involves the decontamination of individuals who have fallen victim to a chemical agent from an attack or an accident involving hazardous materials. Children often are overlooked in disaster planning. Children are vulnerable and have specific medical and psychological requirements. There is a need to develop specific protocols to address pediatric patients who require decontamination at the entrance of hospital emergency departments. Currently, there are no published resources that meet this need. An expert panel convened by the New York City Department of Health and Mental Hygiene developed policies and procedures for the decontamination of pediatric patients. The panel was comprised of experts from a variety of medical and psychosocial areas. Using an iterative process, the panel created guidelines that were approved by the stakeholders and are presented in this paper. These guidelines must be utilized, studied, and modified to increase the likelihood that they will work during an emergency situation.

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Introduction

The use of chemical weapons in wartime has been documented throughout history. During the Peloponnesian war in 429 BC, the Spartans and Thebans attempted to destroy the city of Palatea by creating a hot fire and adding brimstone and pitch. Finely pulverized lime, known for its caustic effects, was used during the reign of Henry III when English sailors used it to blind French sailors. During World War I, widespread use of chemical weapons such as mustard gas on the battlefield prompted the need for decontamination procedures and treatment of injuries arising from their use.¹ Recently, the use of chemical weapons by Saddam Hussein against the Kurdish population² brought chemical warfare and the need for emergency preparedness to the forefront of the national psyche.³ In 1995, members of the religious cult Aum Shinrikyo poisoned civilians riding the Tokyo subway using sarin gas.⁴

Hospital Decontamination

Within the last few years, much emphasis has been placed on disaster preparedness. In the aftermath of the attacks on 11 September 2001, the focus of preparedness has expanded from coping with disasters due to natural hazards such as earthquakes and hurricanes, to coping with disasters caused by human activity, such as terrorist attacks,⁵ and accidents involving hazardous materials. Consequently, many hospitals have been developing systems and protocols

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that direct decontamination of persons who present to the hospital during a disaster.⁶ Hospital decontamination is distinct from first responder or gross decontamination, which ideally should be performed at the scene of the disaster by fire, emergency medical services (EMS), police, or military personnel. Then the decontaminated victims are transported to hospitals for medical treatment. Typically, these protocols do not address the special needs of pediatric patients.

Self-Presentation of Patients

In past disaster planning scenarios, first responder decontamination was the expected norm, and most hospitals expected to receive fully decontaminated patients. This thinking changed after the 1995 sarin gas attack in the Tokyo. In Tokyo, 85% of the exposed patients “self-transported” to hospital facilities without any prehospital intervention or notification.⁴ A similar phenomenon occurred at the Alfred Murrah federal building bombing in Oklahoma City—only 33% of patients were transported to the hospitals by EMS.⁷ The same pattern of self-referral was reported at hospitals in New York City and Washington, DC on 11 September 2001. Many of these patients, including children, were coated with an unknown grey ash, and self-transported to hospitals in lower Manhattan. These facilities were not prepared to decontaminate those exposed. Subsequently, hospitals received funds to establish facilities so that decontamination could occur outside of the hospital.⁸ With the support of hospital administration, staff members from various departments were recruited to train to provide decontamination, and teams were established to ensure continuous coverage. Many hospitals already have made significant alterations in their physical plant by building permanent decontamination showers for contaminated patients in order to protect their healthcare providers and other patients from secondary contamination.^{9–11} However, few have made specific arrangements to cope with one of the most vulnerable populations, children.

Limited Resources for Hospital

In the US, and possibly worldwide, there are limited resources for hospitals to accomplish the goal of being properly prepared to care for children during a disaster, despite a presidential directive¹² that acknowledged that emergency departments are first receivers, and thus, are eligible for first responder resources and funding. In 2005, the US Occupational Safety and Health Administration (OSHA) published a manual entitled, *Hospital-Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances*,¹³ as a guide to promote best practices of preparing and implementing such systems. Despite this, many hospitals still do not have any decontamination plans. There are examples of protocols in mass-casualty mass-decontamination guidance documents for first responders, as well as training programs,^{14,15} but few for hospital-based first receivers.

Threats to Children

Children also are targets for terrorists. Examples include the hostage situation at a school in Beslan, Russia,¹⁶ the

Columbine massacre,¹⁷ the attack at a Jewish community center in Argentina,¹⁸ and the bombing in Oklahoma City.^{19,20} In addition, a large number of daycare centers, schools, and other facilities with a high density of children are potential targets for terrorists.^{3,21} Media quotes from an Al Qaeda spokesperson have said,

*We have not reached parity with them. We have the right to kill four million Americans—two million of them children—and to exile twice as many and wound and cripple hundreds of thousands. Furthermore, it is our right to fight them with chemical and biological weapons, so as to afflict them with the fatal maladies that have afflicted [us] because of the [Americans'] chemical and biological weapons.*²²

Although chemical, radiological, and biological attacks have been infrequent, the threat is real.²³ The proposed protocols outlined also are appropriate for industrial or other accidents involving hazardous materials.

Pediatric Decontamination

The vulnerabilities of pediatric patients during decontamination have been identified in US federally funded documents that call for the creation of decontamination protocols that directly address the special needs of children.^{24,25} Recently, the American Academy of Pediatrics released a policy statement on the impact of chemical and biological terrorism on children²⁶ that advocates specific disaster planning for children, since children have their own set of needs that are distinct from those of adults.²⁷ A literature search revealed that written operating procedures addressing the special needs of infants and children have not been published. The only identified resource to provide guidance is a video that was produced by the Center for Biopreparedness at Children's Hospital in Boston, Massachusetts.²⁸

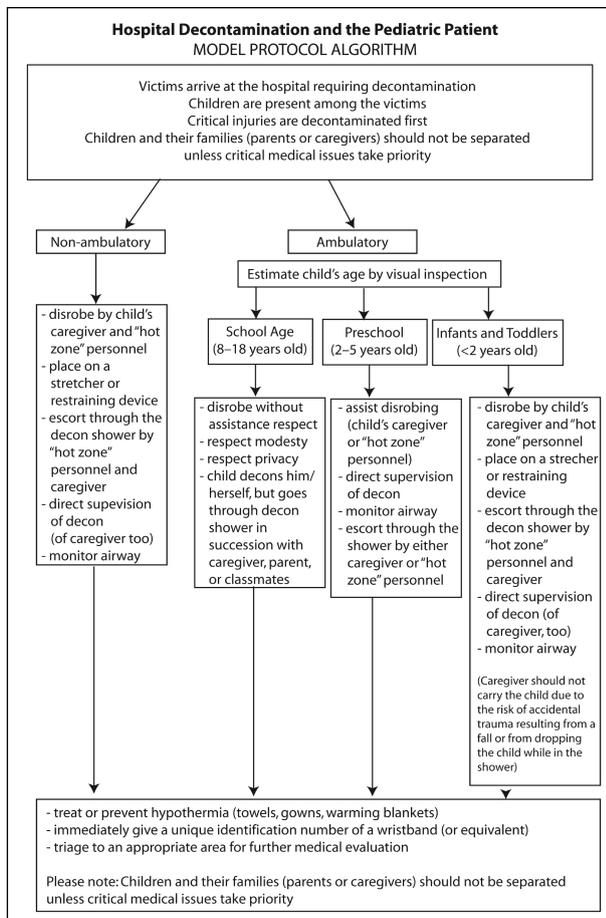
Development of Protocol

Under the auspices of the Hospital Bioterrorism Preparedness Program of the New York City Department of Health and Mental Hygiene, an expert panel, led by the New York Center for Terrorism Preparedness and the Central Brooklyn Center for Bioterrorism Preparedness and Planning, was convened to develop policies and procedures for the decontamination of pediatric patients to be shared with the general pediatric and emergency medicine communities.

These guidelines, which are part of the Pediatric Disaster Toolkit,²⁹ easily can be incorporated into a hospital's current decontamination plan or adopted as an addendum. One chapter is devoted to decontamination of children. Minimal equipment adjustments are necessary to adopt these protocols, and any existing decontamination facility can implement these procedures.

Expert Panel Methods

The expert panel was comprised of people with expertise in: disaster preparedness, emergency medicine, nursing, pediatric emergency medicine, pediatric surgery, public health, social work, and toxicology. *Child life personnel*, professionals who help reduce the stress and anxiety that many children may experience in the hospital and healthcare set-



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Figure 1—Model protocol algorithm

tings, were included in the planning of the protocol. The interventions by child life personnel help children cope during medical procedures or interventions.³⁰⁻³² Therefore, child life personnel should be included as members of the decontamination team.³³

A working group identified issues that are unique to children during decontamination, and presented them to the panel. The panel did not focus on other facets of decontamination that already have been outlined in prior documents. Modifications were made based on input from the expert panel. After several iterative reviews, no new changes were made. From these, a draft set of decontamination guidelines were produced. All controversial issues were discussed by the entire panel during each review meeting, and agreement was reached as to the best method to address each issue. Either there were no controversial issues that were not resolved through this methodology, or most controversial issues were resolved using this methodology, and those issues that could not be resolved are presented in this paper as "unresolved".

Format of Protocol

The protocol is provided in an outline form (Appendix) and also is summarized as a flow chart (Figure 1). Children were categorized by ages into three groups: 9-18 years old,

2-8 years old, and 0 to 2 years old. It often will be necessary to estimate the child's age, since asking may be impractical due to the limitations inherent to the use of the personal protective equipment (PPE) worn by decontamination team members or due to a large influx of patients.

Psychosocial Needs

One of the challenges in dealing with children is that they respond to stress differently than adults and may act younger than their chronologic age. They may be inconsolable or totally withdrawn, and often are unable to follow commands. Children walking through the shower have the potential to frolic or panic and/or become immobile while in the shower, thereby hindering a steady flow of patients through the decontamination process. For those children aware of their surroundings, the added stress of the potential for a terrorist attack is even more distressing³⁴ and they are at high risk for the development of anxiety reactions and/or post-traumatic stress disorder.²⁷ Consequently, even normally verbal children may be unable to provide a medical history or answer questions for a focused examination during pre-decontamination triage. Registration and tracking often is more difficult, because the child may not be able to identify him/herself. Wristbands with whatever information is provided should be put on the children in the cold zone. Polaroid or digital camera have been used for documentation and identification in other countries. However, in the US, camera use is controversial due to privacy issues.

Communication

Pre-school and most school-age children should be able to undress and decontaminate themselves when given clear, short, specific instructions. Communication is difficult for those performing decontamination wearing powered air purifying respirators (PAPR). Shouting instructions through a mask is tiring and only effective for brief instructions, and impractical in chaotic situations. The use of an amplified bullhorn was suggested, but was discarded due to difficulty of lining up microphones with the vent on the hood of the PAPR. Another option is the use of an electronic communication device attached to the protective suits.³⁵ This may be impractical because some children may be scared by the PAPR, and the distorted voices from these devices may exacerbate existing fears. A short cartoon video or simple poster with illustrations of actions that are required may work well and avoid language barriers, and, when necessary, hand signals and gestures also should be employed.

Chaperones

During a disaster, children may present to the hospital with their parents, teachers, caregivers, or other familiar and reassuring persons, who also will require decontamination. Children also may present without a dedicated caregiver. During disasters, children may become more anxious about leaving their parents or caregivers, and young children often show signs of separation anxiety.³⁶ Thus, in the case of accompanied children, all attempts should be made to keep families and familiar caregivers together during and after decontamination. This will reduce anxiety among the

children. For unaccompanied children, a dedicated chaperone, possibly from child life or social work, should be assigned to each child for comfort and reassurance in the cold zone. However, this may be difficult due to the unavailability of staff. A good source of personnel would be to train volunteers prior to an event from the community-at-large.

Removal of Clothing

The undressing of children and their subsequent decontamination may take longer than for an adult. Any parent of a recalcitrant toddler appreciates the effort necessary in undressing a child. Sensitivity and modesty should be maintained, as children often are hesitant to disrobe in the presence of strangers especially of the opposite sex. Therefore, it is preferred that when indicated, someone of the same sex be assigned to assist with undressing.³⁷ Removal of clothing may account for more than 85% of topical decontamination of each victim.²⁶

Holding Infants

Although it is preferred that families decontaminate together, they still will require assistance. It will be difficult for a parent to undress themselves and their children at the same time, especially if they are injured. Experience with newborns has shown that they are difficult to hold when wet. This problem is exacerbated further by the reduced dexterity of hospital personnel wearing chemically resistant gloves and suits. Thus, when indicated, it is recommended that two people handle any transfer of children in the shower, and that the child be held tightly and securely, close to the body of the chaperone. Infant handling positions and procedures where the head is supported in the palm and the body straddles the arm of the provider while tucked under the opposite arm can be employed. This is controversial, and many find it difficult to perform. Thus, the recommendation was made that infants can be placed on a stretcher and decontaminated to decrease the risk of being dropped.

Maintaining Airway

During the decontamination process, maintaining a patent airway is important. Infants have proportionally larger occiputs and lack muscle tone to control their head movement. Thus, proper airway positioning must be maintained manually. It may be useful to move non-ambulatory infants through the shower in a car seat made of plastic or other waterproof material (without the cushion) to maintain the airway in a neutral position, as well as maintaining spinal immobilization, should that be necessary. However, this procedure is difficult due to the inaccessibility of the posterior and sides of the patient to the decontamination shower. For school-age children, a scoop-style stretcher also may be used, which will keep children lateral recumbent. The added weight of the scoop will make decontamination more difficult, and require additional personnel to carry the child. To alleviate this problem, there are commercially available conveyor-like roller systems that can be used to slide a patient on a backboard or scoop stretcher through a decontamination process.³⁸ When such a setup

is unfeasible, using a traditional stretcher with the sides raised be the most practical way to provide total access to the child. Due to the risk of aspiration of the water from the high flow rates of the shower, the child should be placed on a side and not face up. Care should be taken to ensure adequate drainage from the stretcher to avoid water pooling.

Exposure to Toxins

An infant's skin is more permeable and possesses less keratin than does an adult's.³⁹ Children also have a large surface area relative to their body weight, and more toxins may be absorbed.²⁶ Children differ from adults in their capacity to excrete toxic substances. Additionally, because children's organs are in various stages of growth and differentiation, their immune system may be immature, and thus, susceptibility to toxins also varies.⁴⁰ Studies also have shown an increased susceptibility of children to more severe facial and ophthalmic injury than adults. This may be due to their failure to recognize danger and the fact that they do not instinctively cover their faces during the event.⁴¹ Thus, it is important that a careful and thorough decontamination be performed to remove any toxin.

Process of Decontamination

Water pressure should be reduced to approximately 60 psi²⁶ (413.7 kPa), by using "kid-friendly" adapters such as hand-held sprayers that are designed for adjustable pressure, can be adjusted by hospital personnel. The water temperature must be no less than 98°F²⁶ (36.7°C) to prevent the development of hypothermia, which also can be exacerbated by the presence of large cutaneous injuries or previous exposure.⁴⁰ The use of alcohol- or bleach-based cleansers is not recommended due to the potential for development of systemic intoxication. Only water, the oldest known and most effective decontaminant,¹ possibly combined with a low-Alkaline mild soap, but the utility of soap is questionable.²⁶ At the conclusion of the shower, children immediately should be dried and wrapped in a towel or foil-type "space" blanket to avoid the development of hypothermia. At this time, new, dry, sterile bandages and dressings should be applied as required. Special caution should be used in showers exposed to the outdoors to maintain the ambient temperature by using space heaters or lamps and ensuring rapid entry into the triage area. Thus, the distance from the shower to the triage area should be kept to a minimum.

Physiological Concerns

Children have underdeveloped self-preservation skills that make them less able to flee danger, and they may flee into harm's way during the chaotic situation, further increasing their exposure.²⁶ Simple responses such as vomiting, salivation, lacrimation, or sweating as a consequence of their exposure to a toxin may cause more rapid dehydration in children who lack the fluid reserve of adults and have a greater surface area to volume ratio. Hypovolemic shock can be more difficult to ascertain in children who initially compensate, then decompensate with very little warning or change in their vital signs until they are near collapse.⁴⁰

Although difficult and often impractical, hemodynamic monitoring and aggressive fluid resuscitation should be considered.

Conclusions

Planning for decontamination is important to all hospitals. On 9/11, the first patient to present to the New York Veterans Administration Medical Center, which does not have pediatric facilities, was a five-month old child who was in the World Trade Center at the time of the attack and was covered in grey ash. Although circumstances dictated that transfer to a facility with pediatric capabilities was unfeasible, fortunately there were staff well-trained in pediatric emergencies available to care for this infant (and his breast-feeding mother), and the outcome was excellent. This emphasizes the importance that adult-only facilities should have pediatric equipment available and should train for pediatric patients. The pediatric toolkit facilitates pedi-

atric disaster preparedness and can help any facility prepare. Due to the recommendation that families not be separated, it is important that children's hospitals be prepared to treat the caregivers of these children.^{3,42,43} Protocols also should be developed to arrange for the transfer of patients when feasible.

These recommendations and protocols are a work in progress. The inherent emotional and logistical difficulties that these situations present are recognized. To meet the unique needs of all infants, children, adolescents, and young adults, it is critical that the community preparedness efforts involve pediatric healthcare experts and key facilities, institutions, and agencies that care for children. A carefully planned drill with a mock disaster is required in order to test these protocols under simulated, real-world conditions. Further dialogue and revision will be necessary as experience is gained.

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Appendix—Decontamination of the Pediatric Patient Administrative Policy and Procedure (Sample Draft Protocol)²⁹*continued on page 173*

Purpose: This policy and procedure is intended to ensure that all children presenting to any hospital (during an MCI or terrorist attack requiring decontamination) are properly decontaminated in a timely manner. Children require special considerations that may not be addressed in the general Hospital Decontamination Plan.

Policy: It is the policy of the Hospital Decontamination Plan to:

1. Decontaminate all patients presenting to the facility who **potentially** have been exposed to any toxic or harmful substances **before** they enter the facility; and
2. Ensure the safe working environment within the hospital grounds and physical plant for all hospital personnel.

Background: Infants and children have unique needs that require special considerations during the process of hospital-based decontamination.

1. Separation of families should be avoided especially under conditions of large number of patients in a chaotic situation but medical issues take priority (go through the shower together unless one patient is critical);
2. Do not be assume that the parents or caregivers will be able to decontaminate both themselves and their children at the same time (“hot zone” personnel should recognize the need to assist them);
3. Older children may resist or be difficult to handle out of fear, peer pressure, and modesty (even in front of their parents or caregivers);
4. If the water temperature is below 98°F (36.7°C), the risk of inducing hypothermia increases proportionately with the smaller, younger child and thus, temperatures should be maintained slightly above this level;
5. Airway management through the shower is a priority; and
6. Large volume, low pressure water delivery systems (e.g., handheld hose sprayers) that are “child-friendly” need to be incorporated into the hospital decontamination showers. This is the same for non-ambulatory stretcher adult patients.

Children <2 years of age

Infants and toddlers represent the most challenging group in which these special needs considerations are the most important.

1. All infants and toddlers should be placed on a stretcher and disrobed by either the child’s caregiver or “hot zone” personnel. All clothes and items that cannot be decontaminated should be placed in appropriate containers or bags as provided by the hospital and appropriately labeled;
2. Ambulatory children should be accompanied through the decontamination shower by either the child’s caregiver or “hot zone” personnel to ensure the entire patient is properly decontaminated. It is not recommended that the child be separated from family members or adult caregiver. ***It is not recommended that the caregiver carry the child due to the possibility of injury resulting from a fall, or from dropping a slippery and squirming child.*** Special attention must be given to presurring the child’s airway while in the shower;
3. Non-ambulatory children will be placed on a stretcher by “hot zone” personnel and disrobed (using trauma shears if necessary). All clothes and items that cannot be decontaminated should be placed in appropriate containers or bags as provided by the hospital and labeled;
4. Each non-ambulatory child should be escorted through the decontamination shower by either the child’s caregiver or “hot zone” personnel to ensure the entire patient is properly decontaminated. Special attention must be paid to the pressuring the integrity of the child’s airway while in the shower;
5. Once through the shower, the child’s caregiver or “cold zone” personnel will be given a towel and sheets to dry the child, and a hospital gown. Immediately, the child should be given a unique identification number on a wristband and then triaged to an appropriate area for medical evaluation; and
6. Children and their families (parents or caregivers) should not be separated unless critical medical issues take priority.

Children 2 to 8 years of age

From age 2 to 8 years, children should be able to walk and speak, yet still will look like a child with considerable variations in physiology and anatomy.

1. Ambulatory children should be assisted in disrobing by either the child’s caregiver or “hot zone” personnel. All clothes and items that cannot be decontaminated should be placed in appropriate containers or bags as provided by the hospital and labeled;
2. Ambulatory children should be directly accompanied through the shower by either the child’s caregiver or “hot zone” personnel to ensure the entire patient is properly decontaminated. It is recommended that the child not be separated from family member(s) or the adult caregiver;
3. Non-ambulatory children should be placed on a stretcher by “hot zone” personnel and disrobed (using trauma shears if necessary). All clothes and items that cannot be decontaminated should be placed in appropriate containers or bags as provided by the hospital and labeled;
4. Each non-ambulatory child on a stretcher is escorted through the decontamination shower and assisted with decontamination to ensure the entire patient is properly decontaminated;
5. Once through the shower, each child should be given a towel and sheets to dry, and a hospital gown. Immediately, the child should be given a unique identification number on a wristband and then, triaged to an appropriate area for medical evaluation; and
6. Children and their families (parents or caregivers) should not be separated unless critical medical issues take priority.

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Appendix—Decontamination of the Pediatric Patient Administrative Policy and Procedure (Sample Draft Protocol)²⁹
continued from page 172

Children 8 to 18 years of age (school age)

At the age of 8 years and upward, the airway anatomy approximates that of an adult. Although it is tempting to regard this age group as “small adults”, there are special needs unique to this age group.

1. Ambulatory children should disrobe when instructed to do so by “hot zone” personnel. All clothes and items that cannot be decontaminated should be placed in appropriate containers or bags as provided by the hospital and labeled;
2. Ambulatory children should then walk through the decontamination shower, preferably accompanied by their parent or caregiver, and should decontaminate him/herself. Guidance should be provided to the child (and parent/caregiver) during the decontamination process;
3. Non-ambulatory children should be placed on a stretcher by “hot zone” personnel and disrobed (using trauma shears if necessary). All clothes and items that cannot be decontaminated should be placed in appropriate containers or bags as provided by the hospital and labeled;
4. Then each non-ambulatory child is escorted through the decontamination shower and assisted with decontamination to ensure the entire patient is properly decontaminated;
5. Once through the shower, each child will be given a towel and sheets to dry, and a hospital gown. Immediately, the child should be given a unique identification number on a wristband and then triaged to an appropriate area for medical evaluation.
6. Children and their families (parents or caregivers) should not be separated unless critical medical issues take priority.

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