Bioterrorism and children: unique concerns with infection control and vaccination

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The intentional release of biologic or chemical agents directed against a civilian population by domestic or international terrorist groups is a growing concern in the United States. The will to use biologic and chemical weapons against civilians was demonstrated by the dispersal of anthrax spores in 2001 in the United States [1] and the release of anthrax, botulinum toxin, *Coxiella burnetii*, and sarin gas into the Tokyo subway system in 1995 by the Aum Shinrikyo cult [2,3]. The unsuccessful attempt to release a chloride gas bomb at Disneyland demonstrates that terrorists may specifically target children [4]. Children may be more vulnerable to biologic agents than adults because of their higher metabolic and respiratory rates, their proximity to the ground, and their frequent hand-mouth contact. In addition, they may act as vectors through nuclear and extended families, day care, and school systems. The Centers for Disease Control and Prevention (CDC) have developed a list of critical biological agents (Table 1) and have categorized them [5,6] based on the

1. Severity of impact on public health, high mortality rates, and transmission from person to person
2. Potential for delivery as a weapon and ease of dissemination
3. Requirement for special public health preparedness, such as medication or vaccine stockpiling or special laboratory techniques
4. Ability to create public panic or terror

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Infection control in children

Infection control following a biologic agent attack is complex, with some added considerations for the pediatric population. First, early attribution of a cluster of febrile, respiratory illnesses to an intentional biologic agent attack in children might be difficult because children experience respiratory symptoms with common colds more often than adults, and they cannot easily report the subtleties of their own symptoms [7]. Furthermore, strict isolation is complicated in children. Young patients might need to be sedated, especially if isolated in negative pressure tents or rooms. Parents might need to remain with their children in isolation, which can expose them to the infectious agents. In addition, pediatric hospitals need to prepare to care not only for the sick children but also for their

Table 1
Critical biologic agents

Category A[a]	Category B[b]	Category C[c]
Anthrax (*Bacillus anthracis*)	Brucellosis (*Brucella* spcp)	Emerging infectious diseases such as Nipah virus and Hantavirus
Botulism (*Clostridium botulinum* toxin)	Epsilon toxin of *Clostridium perfringens*	
Plague (*Yersinia pestis*)	Food safety threats (eg, *Salmonella* spcp, *Escherichia coli* O157:H7, *Shigella*)	
Smallpox (variola major)		
Tularemia (*Francisella tularensis*)	Glanders (*Burkholderia mallei*)	
Viral hemorrhagic fevers (filoviruses [eg, Ebola, Marburg] and arenaviruses [eg, Lassa, Machupo])	Melioidosis (*Burkholderia pseudomallei*)	
	Psittacosis (*Chlamydia psittaci*)	
	Q fever (*Coxiella burnetii*)	
	Ricin toxin from *Ricinus communis* (castor beans)	
	Staphylococcal enterotoxin B	
	Typhus fever (*Rickettsia prowazekii*)	
	Viral encephalitis (alphaviruses [eg, Venezuelan equine encephalitis, Eastern equine encephalitis, Western equine encephalitis])	
	Water safety threats (eg, *Vibrio cholerae*, *Cryptosporidium parvum*)	

[a] Category A: The US public health system and primary healthcare providers must be prepared to address various biologic agents, including pathogens that are rarely seen in the United States. High-priority agents include organisms that pose a risk to national security because they can be easily disseminated or transmitted from person to person; result in high mortality rates and have the potential for major public health impact; might cause public panic and social disruption; and require special action for public health preparedness.

[b] Category B Diseases/Agents: second highest priority agents include those that are moderately easy to disseminate; result in moderate morbidity rates and low mortality rates; and require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance.

[c] Category C Diseases/Agents: third highest priority agents include emerging pathogens that could be engineered for mass dissemination in the future because of availability; ease of production and dissemination; and potential for high morbidity and mortality rates and major health impact.

parents if separation is to be avoided. Prolonged isolation can dramatically affect children's and parent's well being and their social relations [8]. Pediatric infection control after a bioterrorist event is even further complicated by the fact that there is little consistency in design, structure, organization, and implementation of infection control throughout pediatric facilities in the United States [9]. Unresolved current controversies in pediatric isolation and infection control include the correct application of standard precautions and best precautions to prevent transmission of disease [10]. Four general issues of infection control in pediatrics apply regardless of whether bioterrorism is involved:

1. Early recognition and identification of agent
2. Notification of public health agencies
3. Decontamination, infection control safety measures, isolation, and quarantine
4. Treatment, prophylaxis, and vaccination

Early recognition and identification of agent

"Chance favors the prepared mind" said Pasteur, and preparedness requires that clinicians and public health institutions remain aware of the possibility of bioterrorism at all times. Moreover, medical schools and postgraduate medical education curricula must include cognitive and training aspects of "bioterrorism medicine" and take a leadership role in instructing physicians and other members of the health care team about bioterrorism crisis management [11–13]. Clues that suggest the possible release of a biologic agent include:

1. Multiple patients with unexplained, similar serious illnesses, especially acute severe pneumonia
2. A cluster of diseases that are caused by agents known to be possible biologic weapons, as defined by the CDC [6]
3. An outbreak of infectious disease without natural explanation or outside its natural location
4. Serious illnesses with unusual clinical manifestation, unusual organisms, or unusual antibiotic resistance patterns
5. Unexplained illness or death in animals
6. Public claim of release of a biologic weapon or intelligence information [12,14]

Early detection surveillance systems have been developed [15,16] and most often are based on automated medical records. Several automated surveillance systems and their value in detecting disease clusters have been described [17,18]. The principal focus is generally on identifying unusual patterns of apparently common respiratory, gastrointestinal, or other illnesses in a population, although identification of a specific biologic agent can be difficult for laboratories. The

CDC or US Army Medical Research Institute of Infectious Diseases should be consulted before analysis of samples, and the examining laboratory must be warned that a biological agent is suspected.

Notification of public health agencies

Early notification of public health authorities and law enforcement agencies is essential if a biologic attack is suspected, even if the pathogens have not yet been positively identified. A directory of public health authorities and resources should be readily available to health care providers, and an incident command system should be integrated into emergency preparedness plans [19]. Local telephone directories contain telephone numbers of local public health facilities, local Federal Bureau of Investigation offices and other resources. The CDC has a telephone hotline number, 770-488-7100, and the telephone hotline number for the US Army Medical Research Institute of Infectious Diseases is 888-872-7443.

Decontamination, infection control safety measures, isolation, and quarantine

Planning for a biologic agent incident must include the protection of health care providers, patients, families, the hospital or other facility and its environment. Decontamination of victims after the release of a biologic agent is less important than during a chemical or radiologic attack because most patients would seek medical care after the incubation period, having decontaminated themselves during this period with showers and clothing changes. In contrast, an announced attack with aerosolized biologic agents would require decontamination. Decontamination with water can cause significant heat loss in children because of their larger surface to body area. Hypothermia can occur without precautions such as the use of warming lights or blankets [4]. Decontamination similar to that recommended after a chemical attack might be necessary [19] Health care professionals who help to decontaminate patients or handle contaminated clothing must wear a gown, gloves, head and shoe covers, and an N95 (disposable) respirator. N-95 respirators are often used in tuberculosis (TB) isolation rooms, in transport of TB cases, or in other areas of the health care facility. When high-risk procedures such as bronchoscopy or necroscopy are conducted, respiratory protection exceeding the CDC standard performance criteria may be needed, such as full face piece negative-pressure respirators, powered air-purifying respirators (PAPRs), or positive-pressure airline-type respirators equipped with a half-mask or full face piece. Contaminated clothing must be placed in biohazard bags to avoid reaerosolization. If necessary, environmental surfaces should be cleaned with a solution of 10% hypochlorite. A 70% alcohol solution can be used after 10 minutes to continue the decontamination.

Infection control safety measures needed for class A bioterrorism agents

Standard precautions

Smallpox, viral hemorrhagic fevers, and plague are transmitted from person to person and pose the greatest challenge to infection control (Table 2). Tularemia, anthrax, and botulism are not transmitted from person to person in their naturally occurring forms. Standard precautions are sufficient for patients infected with these organisms. These precautions are designed to reduce the risk of transmission of blood-borne pathogens and pathogens from moist body substances and apply to all patients receiving care in hospitals, regardless of their diagnosis or presumed infection status. Standard precautions apply to blood, all body fluids, secretions, and excretions except sweat, regardless of whether or not they contain visible blood, non-intact skin, and mucous membranes [20].

Droplet transmission precautions

Plague and viral hemorrhagic fevers are believed to be spread by droplet nuclei. Caregivers, including anesthesiologists, are particularly susceptible to sec-

Table 2
The greatest challenges to infection control

Disease	Infection control measures
Smallpox	All hospital employees as well as patients in hospital need to be vaccinated. Individuals for whom vaccination is contraindicated; VIG should be provided. Patients should be isolated in rooms with negative airflow and equipped with HEPA filtration. Standard precautions such as gloves, gowns, and masks should be observed. All laundry and waste shoud be placed in biohazard bags and autoclaved before being laundered or incinerated. Laboratory examination requires high-containment (BL-4) facilities. Mortuary workers need to be vaccinated, and cremation is recommended.
Plague	Respiratory droplet precautions (gown, gloves, and eye protection). Patient needs to be isolated during first 48 h of antibiotic treatment. Patients who require surgery that can generate particulate aerosols need to be cared for in negative pressure rooms, and operating room personnel should use HEPA filtered masks.
Tularemia	Standard precautions; no need for isolation. Patients who require surgery that can generate particulate aerosols need to be cared for in negative pressure rooms, and operating room personnel should use HEPA filtered masks.
Anthrax	Standard barrier precautions for all types of anthrax infections
Hemorrhagic fever viruses	Strict adherence to hand hygiene, double gloves, impermeable gowns, N-95 masks or powered air-purifying respirators Negative isolation room Leg and shoe coverings Face shields, goggles Dedicated medical equipment
Botulinism	Standard precautions

ondary infection by organisms spread by droplet nuclei. In a case control study of 253 health care personnel exposed to 11 index cases of severe acute respiratory syndrome in five Hong Kong hospitals, 69 staff members who used complete droplet and contact precautions (surgical masks, gloves, gowns, and hand washing) were not infected, whereas all infected staff (13 of 253) had omitted at least one safety measure [21]. Two of the infected staff were physicians.

Droplet transmission involves contact of the conjunctivae or the mucous membranes of the nose or mouth of a susceptible person with large-particle droplets (larger than 5 μm in size) containing microorganisms generated from a person who has a clinical disease or who is a carrier of the microorganism [20]. Droplets are generated from the source person primarily during coughing, sneezing, or talking, and during the performance of certain procedures such as suctioning and bronchoscopy. Transmission by large-particle droplets requires close contact between the source and the recipient because the droplets do not remain suspended in the air and generally travel only short distances (3 feet or less). Special air handling and ventilation are not required because the droplets do not remain suspended in the air.

Airborne transmission precautions

Although most infectious disease specialists believe that viral hemorrhagic fever is transmitted by droplet nuclei, there are some reports that suggest airborne transmission [22]. Indeed, most institutions would use airborne, droplet, and contact precautions for any patient suspected of being infected by viral hemorrhagic fever or smallpox. Hands should be cleaned before patient contact and should be double gloved. Watches, jewelry, and artificial fingernails should be removed from hands [23]. Beepers and cellular phones should also be removed. Impermeable gowns, face shields, goggles, and hair covers must be worn. N-95 masks or PAPRs are recommended. Experts have suggested the use of PAPRs for endotracheal intubation [23]. Waterproof leg and shoe covers are also advisable. After patient contact, gowns, leg and shoe covers need to be removed, and hands should be washed with disinfectant solutions. After hand cleaning, facemasks, respirators, shields, goggles, and hair protection should be removed to decrease exposure to mucous membranes and eyes from potentially contaminated hands [22]. If decontamination is necessary, appropriate personal protective attire is to be used.

Patients should be placed in private rooms with negative-pressure systems. In an outbreak in Germany in 1970, one isolated victim infected patients on three different floors [24]. In larger outbreaks, administrative decisions may need to be made about grouping patients in separate hospital wings or in separate hospitals for smallpox victims, or isolating patients at home. Air should pass through high-efficiency particulate air (HEPA) filters before being exhausted outdoors [25,26]. In mass casualty situations, patients should be placed in the same part of the hospital. Access to patients should be restricted to only essential health care

professionals and visitors, lest the rest of the institution and its personnel and visitors be contaminated. Patients should only be transported when absolutely indicated, and immediate cleaning and disinfection should follow the patient's path. It is helpful to transport patients in commercially available negative-pressure tents. Pediatric patients might need to be sedated for such transport, for example, from the emergency department to the isolation room, potentially involving anesthesiologists directly. Health care workers, visitors, laboratory workers, and other potentially exposed persons should be under medical surveillance for at least 21 days.

Linen should be placed in two waterproof bags and washed in hot water with bleach, autoclaved, or incinerated. Terminal room cleaning and equipment disinfection should be carried out with a solution of household bleach diluted 1:100. Medical waste should be handled with extreme precautions. Laboratory personnel must be alerted if the disease is suspected. From a safety and public health perspective, surgery or post-mortem care should be avoided [25].

Treatment and vaccination

Once a bioterrorist attack has been confirmed and symptomatic patients identified, the next step in infection control is to limit the spread of the biologic agents. Currently, there is a vaccine available for anthrax, although it is recommended for people over the age of 18; and there is a vaccine for Ebola virus [27,28], a devastating type of viral hemorrhagic fever that is just entering clinical trials. Routine smallpox vaccination of children in the United States at the age of 1 year was stopped in 1972, and the disease was considered eradicated in 1980. The strain of vaccinia used for the smallpox vaccine in the United States is the New York Board of Health strain, which is considered one of the strains of vaccinia least likely to cause complications; however, the complications of smallpox vaccination, although rare, can be devastating (Table 3).

Vaccinating susceptible populations against bioterrorism agents before exposure is one strategy to limit the effects of a bioterrorism attack. In 2003, the United States government initiated a pre-event vaccination program for selected health care providers, to provide direct medical care for victims of a bioterrorism attack with suspected smallpox for the first 48 hours, until additional health care workers could be vaccinated [29]. Pediatricians, pediatric intensivists, and anesthesiologists were included in the group of targeted health care providers. As of January 2004, the CDC released approximately 200,000 doses of vaccine but only 39,000 doses have been administered for this voluntary program, amid concerns about liability and adverse reactions (Table 3) [30].

The second strategy to control and limit the extent of a smallpox outbreak is to interrupt disease transmission by isolation and vaccination of primary contacts of the affected individuals and then vaccination of close contacts of the primary contacts (secondary contacts), thereby creating a ring of immune individuals around the affected individual. It is conservatively estimated that these rings of

Table 3
Rates of reported complications associated with vaccinia vaccinations (cases/million vaccination)

Age (yrs) and status	Inadvertent inoculation	Generalized vaccinia	Eczema vaccinatum	Progressive vaccinia	Postvaccinial encephalitis	Total
Primary vaccination						
≤ 1	507.0	394.4	14.1	—	42.3	1549.3
1–4	577.3	233.4	44.2	3.2	9.5	1261.8
5–19	371.2	139.7	34.9	—	8.7	855.9
≥ 20	606.1	212.1	30.3	—	—	1515.2
Overall rates	529.2	241.5	38.5	1.5	12.3	1253.8
Revaccination						
≤ 1	—	—	—	—	—	—
1–4	109.1	—	—	—	—	200.0
5–19	47.7	9.9	2.0	—	—	85.5
≥ 20	25.0	9.1	4.5	6.8	—	113.6
Overall rates	42.1	9.0	3.0	3.0	—	108.2

Data from Lane JM, Ruben FL, Neff JM, Millar JD. Complications of smallpox vaccination, 1968: results from 10 statewide surveys. J Infect Dis 1970;122:303–9.

people who would need to be emergently vaccinated during a smallpox outbreak could number in the thousands [29]. There is some evidence that vaccinating contacts up to 4 days after exposure to a smallpox patient will either prevent or ameliorate the disease [26,31]. Although voluntary vaccination is not recommended under the age of 18 as part of the pre-event vaccination program, it is very likely that children would be included in any vaccination program of close contacts of smallpox victims [32].

Approximately one half of the US population has not been vaccinated because routine vaccination for smallpox in the United States ended [33], and it is unclear what the immunization status is of the other half of the population [34]. In the era of routine vaccination, the rate and severity of complications were greatest in children under the age of 5 [35], and the overall mortality rate was 1 per million primary vaccinations [36]. There are reliable data from the 1960s about the incidence and nature of adverse reactions to vaccination, but it may be that the incidence of adverse reactions to a national vaccination program would be higher now because more of the population is immunocompromised, and the incidence of childhood atopy has risen [37,38]. Elective vaccination is not recommended for certain population groups, although, in the event of an exposure to smallpox, the risks of the vaccination need to be weighed against the risks of clinical disease. In most cases, the patients that are most vulnerable to developing a complication from vaccination are also the patients that would be most at risk for developing smallpox. Thus, there are relative but no absolute vaccination contraindications. The CDC has defined 11 relative contraindications to vaccination (Box 1).

After primary vaccination, live vaccinia virus can be recovered at the vaccination site from the development of the papule at 2 to 5 days after vaccination, until the scab is shed at 14 to 21 days. During this time, accidental inoculation may occur to other parts of the body or to other susceptible

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Box 1. Patients who should not get the smallpox vaccine unless they are exposed to smallpox[a]

The following individuals who should not receive smallpox vaccine have or are:

1. Eczema, or atopic dermatitis
2. Skin conditions such as burns, chicken pox, shingles, impetigo, herpes, severe acne, or psoriasis
3. Weakened immune system
4. Pregnant
5. Allergies to vaccine or its ingredients (polymyxin B, streptomycin, chlortetracycline, neomycin)
6. Less than 12 months of age (ACIP recommends < 18 years of age)
7. Moderate or severe short-term illness
8. Breast feeding
9. Using steroid drops in their eyes
10. A heart condition
11. Three or more risk factors: high blood pressure, high blood cholesterol, diabetes, a first-degree relative who had a heart condition before the age of 50 and who smoke cigarettes

[a]*Data from* CDC smallpox fact sheet [CDC web site]. People who should not get the smallpox vaccine (unless they are exposed to smallpox). Available at: http://www.bt.cdc.gov/agent/smallpox/vaccination/contraindications-public.asp. Accessed November 5, 2003.

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individuals. Transmission usually occurs by close personal contact. The Advisory Committee on Immunization Practices of the Department of Health and Human Services has recommended that recently vaccinated health care workers be allowed to maintain patient care duties using rigid infection control procedures. These procedures include dressing the vaccination site with gauze and a semipermeable dressing and covering the area with a layer of clothing. In addition, scrupulous hand hygiene needs to be maintained after any contact with the vaccination site or the dressings [29].

Adverse reactions and complications

The most common adverse reaction is fever, with 70% of children having a fever of up to 100° for 1 day and up to 20% having a fever of greater than 102°.

The incidence of fever in adults is much less, with only 5% to 9% reporting mild fevers and only 3% reporting a fever higher than 102° [39]. In addition, approximately one half of recipients report mild pain at the site, and one third develop mild lymphadenopathy. Some patients exhibit hypersensitivity reactions to the vaccinations such as erythema multiforme and Stevens–Johnson syndrome. Treatment is supportive and may include steroids.

The most common vaccinia-specific complication is autoinoculation, which occurs when vaccinia from the vaccination site is spread to another site on the body such as the eye, mouth, genitals, or anus. This complication occurred at a rate of 529 per million primary vaccinations in the United States [35] and was most common in children 1 to 4 years of age. It is usually self-limited unless it occurs in the eye. Vaccinia can cause a keratitis leading to corneal scarring, which may be exacerbated if vaccinia immune globulin (VIG) is used for treatment.

Generalized vaccinia occurs at a rate of 241 cases per million primary vaccinations. It is characterized by a disseminated maculopapular or vesicular rash that can be distinguished from variola because the rash does not follow the centrifugal pattern of smallpox [38]. Because the lesions of generalized vaccinia are believed to contain live vaccinia virus, patients need to be treated with contact precautions and isolated if possible. Treatment with VIG is usually not necessary unless the patient is immunocompromised.

Eczema vaccinatum can be a life-threatening complication that occurs at a rate of 38 cases per million primary vaccinations [38]. It occurs in patients with atopic dermatitis or eczema and is most severe in individuals who are undergoing their primary vaccination or are in close contact with recently vaccinated individuals. The lesions are characterized by a localized or generalized papular, vesicular, or pustular rash that occurs anywhere in the body, with a predilection for areas of previous atopic dermatitis [38]. The lesions occur at the same time as the initial vaccination lesion. The mortality from this complication has been reported to be as high as 30% and can be significantly reduced by the early use of VIG. Because these patients are capable of transmitting vaccinia to unvaccinated individuals, these patients need to be isolated and contact precautions observed.

Progressive vaccinia rarely occurs during routine vaccinations, with an incidence of 1.5 cases per million vaccinations reported [35]. This disorder occurs in patients with an immunodeficiency and may be more severe in patients with cell-mediated rather than those with humoral deficiencies [40]. This complication is characterized by unchecked growth of the vaccinia virus at the site of inoculation leading to necrosis and nonhealing of the initial vaccination lesion. This complication was universally lethal before VIG was introduced but still has a high mortality rate. Patients with this are infectious, so contact and isolation precautions need to be taken.

Infants less than 12 months of age are at an especially high risk for postvaccinial central nervous system disease. Postvaccinial encephalitis (encephalomyelitis) occurs at a rate of 12 cases per million primary vaccinations, but the rate for children less than 12 months of age is 42 cases per million primary vaccinations [32]. The cause of this disorder is unknown, although it appears to

be similar to other postinfectious encephalitides with symptoms developing 6 to 10 days after vaccination. In the past, approximately 25% of patients were left with significant neurologic deficits, and 25% of patients died. This complication was more commonly found in patients who were vaccinated with a strain of vaccinia not used in Canada, and the US VIG administered prophylactically has resulted in a decreased incidence of postvaccinial encephalitis in military recruits in Europe; thus, VIG is administered with all first-time vaccinations in the Netherlands, a practice not recommended in the United States [41,42].

Fetal vaccinia has been reported less than 50 times and has occurred in all three trimesters of pregnancy. It is associated with a high incidence of fetal demise but not with prematurity or congenital anomalies. Babies demonstrate the lesions of generalized vaccinia and need to be treated with contact and isolation precautions. There are no data on the efficacy of VIG in treating these infants.

Myopericarditis has never been reported as a complication of smallpox vaccination in young children, although it has been reported in military recruits and civilians taking part in the recent pre-event vaccination program. Eleven cases have been reported among the approximately 325,000 primary vaccinees in the military vaccination program, and two cases have been reported among civilians [43]. In addition, there have been five civilian patients with cardiac ischemic events following vaccination. The causal relationship between the cardiac ischemic events and the smallpox vaccination is unclear, but there does

Table 4
Biologic agents and suggested treatments

Biologic agents	Suggested treatments	Prophylaxis
Botulinism	Antitoxin, supportive	
Anthrax	Ciprofloxin,[a] doxycylcine,[b] or penicillin[c] with streptomycin[d]	Ciprofloxin or doxycline Anthrax vaccine[d]
Tularemia	Streptomycin or gentamicin	Doxycycline or tetracycline
Plague	Streptomycin or gentamicin; doxycyline or chloramphenicol	Doxycycline or tetracycline
Smallpox	Cidovir[e]	Smallpox vaccination within 4 days of exposure
Viral hemorrhagic fever	Ribavarin[f]	

[a] Ciprofloxin is not approved by the Food and Drugs Administration for children less than 18 years of age.

[b] Doxycycline and other tetracyclines are not recommended for childen less than 8 years of age but are indicated for serious infections.

[c] Penicillin should be used for treatment only if the organism is known to be susceptible.

[d] Vaccine is not FDA approved and has only been used in persons 18 years and older.

[e] Cidovir has never been used in smallpox treatment but has been used in monkeypox treatment in adults.

[f] Ribavarin is effective for arenavirus or bunyavirus but not filovirus or flavovirus and is not FDA approved for children.

appear to be a causal relationship between vaccination and myocarditis. These recent reports of cardiac complications have led the Advisory Committee on Immunization Practices to revise their recommendations to exclude individuals with known heart disease or three or more cardiac risk factors [44].

Governmental planning for a bioterror attack from smallpox presupposes that the smallpox released would be "natural" and not genetically modified. Recently, mousepox has been genetically engineered, creating a strain with 100% mortality for the mice [45]. Even vaccinated mice were not fully protected. Subsequent work on this genetically modified virus has revealed that vaccinated mice that were also treated with cidovir fared much better than mice that received just the vaccine or just cidovir. Although there are no studies on the efficacy of cidovir on treating smallpox, this drug has been used to treat vaccinia, monkeypox, and mousepox [46]. Suggested treatment for the other class A bioterror agents is reviewed in Table 4.

Summary

Children may be especially vulnerable to bioterrorism attacks because of their higher metabolic and respiratory rates, their frequent hand-to-mouth contacts, and their proximity to the ground. The treatments available against biologic agents that may be used in a bioterror incident have all been designed for and tested in adults and are often relatively contraindicated in children. Moreover, the usual methods needed to contain a bioterrorism attack are more difficult to implement in a pediatric setting. The vaccines available either have not been recommended or used extensively in children (eg, anthrax) or have been proven to have more adverse effects in very young children (eg, smallpox). Effective infection control measures are more difficult to maintain in a population that psychologically and physically resists isolation measures. In fact, it is very possible that young children will need to be sedated if isolation from parents is necessary, which would require the active role of pediatric intensivists and anesthesiologists.

Until the introduction of effective antibiotics and vaccines for common pediatric infections, pediatric hospitals limited the spread of disease by placing young patients in quarantine in specific wards while they were infectious. Ironically, the success in eliminating infection as the most common cause of pediatric mortality over the last 50 years is that pediatric hospitals are no longer designed for quarantine, which would be required following a bioterrorism attack. Indeed, the difficulties in vaccinating a cadre of health care workers against smallpox were highlighted by the sparse participation of health care workers in the voluntary program initiated by the US government. Several pediatric institutions declined to participate at all and others had minimal participation. Presently, it is prudent to assume that children are extremely vulnerable to bioterrorism attacks and that the pediatric health care system is not fully prepared to deal with bioterrorism.

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