Critical Decisions In Emergency Medicine™

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Derm and Doom: The Common Rashes of Chemical and Biological Terrorism

Objectives

On completion of this lesson, you should be able to:

1. Recognize and discuss the rashes and lesions caused by chemical and biological warfare agents.
2. Describe the treatment of patients exposed to these agents.

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The possibility of terrorism in our country is real and will likely involve the use of chemical and biological agents. Many of these agents will initially cause skin rashes and lesions. Emergency departments are ill prepared to recognize and treat patients exposed to chemical and biological weapons of mass destruction (WMD). Training and exercises have primarily focused on scenarios involving sarin or other chemical nerve agents. Even fewer training events have included scenarios using biological agents. Scenarios rarely involve chemical or biological agents with dermal effects as a primary focus. Hence, responders and providers may be unprepared to recognize and treat patients presenting predominantly with dermal manifestations after a WMD exposure.

Emergency physicians have some experience with patients presenting with dermal symptoms of chemical or biological agents of non-WMD origin. These include patients who have been involved in industrial, transportation, and agricultural accidents and exposed to chlorine, anhydrous ammonia, and other hazardous materials. In these circumstances, the primary symptoms usually are not dermal, but respiratory and ophthalmic. Other dermal presentations of a non-WMD origin that emergency physicians see frequently include childhood illnesses, eg, varicella (chicken pox) and impetigo.

This article will review the dermal effects and symptoms of chemical and biological weapons that emergency physicians would most likely need to recognize and treat. Chemical agents of WMD origin include vesicants and riot control agents. Biological agents of WMD origin causing dermal effects and symptoms include various bacteria, viruses, and toxins.

Case Presentation

Students at a local university are staging a protest march against global free trade. Some students start to express their anger with more than chants. A group of students turn over a car, and the university administration calls the police. The police arrive and disperse riot control agents—tear gas and Mace. Emergency medical services are called to the scene and find that many students are coughing.

An 18-year-old male student complains to the paramedics that he cannot breathe. On examination, he is found to be experiencing respiratory distress with stridor. He complains that his skin is itching. The skin shows some erythema and a few vesicles. A lung examination reveals some wheezing and stridor. He says he has been in other demonstrations where tear gas was used, but it had never affected him like this before.

A 36-year-old man presents to the emergency department with a "cold" of 3 days' duration. The patient describes malaise, fever, rigors, vomiting, headache, and backache. He says he feels so poorly from his illness that he has stayed in bed for the past 2 days. On physical examination, he appears toxic, and vital signs are blood pressure 130/80, pulse rate 125, respiratory rate 25, and temperature 39.4°C (103°F). He has enlarged axillary lymph nodes and splenomegaly. He has a rash on his face, hands, and forearms that he states started on his face. The lesions are well described and include hard pustules. They are at the same stage of development in different parts of the body, and some of the older lesions on the face are confluent. The lesions are concentrated on the extremities and face, with relatively few on the trunk.

Also in This Issue
Mass Casualty Management: A Coordinated Response, page 7

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Critical Decisions

- How do you identify patients who have been exposed to vesicants?
- What is the antidote for patients exposed to arsenicals?
- What is the best method for decontaminating patients exposed to riot control agents?
- How do you identify patients with smallpox?
- Which patients exposed to biological agents of weapons of mass destruction require isolation?

Chemical Agents

Chemical agents of WMD origin with dermal effects and symptoms include two categories of chemicals: 1) the vesicants (eg, sulfur mustard), arsenicals (eg, Lewisite), and phosgene oxime; and 2) riot control agents such as chloroacetophenone (CN) (Mace) and orthochloro-benzalmalonitrile (CS) (tear gas).

Critical Decisions: *How do you identify patients who have been exposed to vesicants?*

The effects and symptoms of vesicants vary by the agent, but all create blistering lesions on the skin.

Mustard is a persistent agent on the skin with low volatility. It is an oily liquid that smells like mustard. The median lethal dose is 100 mg/kg (7 g for a person weighing 70 kg) or 1 to 1.5 teaspoons of liquid over 25% of body surface area. It most commonly affects skin, eyes, and airway. A large amount can affect the hemopoietic system, gastrointestinal tract, and central nervous system (CNS). Mustard agent can produce immune suppression. Skin effects manifest primarily in warm, moist, thin areas such as the perineum, genitalia, axillae, antecubital fossa, and neck. The mildest and earliest dermal injury is erythema (it looks like sunburn). The appearance of small vesicles with surrounding erythema ("string of pearls") is unique to mustard agent. The onset of erythema is 4 to 8 hours postexposure. Vesication begins 2 to 18 hours later and may not be complete for days. Typical bullae are dome-shaped, thin-walled, superficial, translucent, yellowish, and 0.5 to 5 cm in diameter or larger. The vapor can cause first- and second-degree burns; the liquid can cause third-degree burns. Patients with exposure to high doses of liquid develop lesions with a central zone of coagulation necrosis and peripheral blisters (Figure 1).

Arsenicals (eg, Lewisite) are oily, colorless liquids that smell like geraniums and are more volatile and persistent than mustard. Arsenical toxicity is similar to mustard in damage to skin, eyes, and airway by direct contact, with systemic effects after absorption. Exposure to a large amount of arsenical agent can cause "Lewisite shock," the result of protein and plasma leakage from capillaries that leads to hemoconcentration and hypotension. Patients initially complain of pain and irritation that begins within seconds to minutes of dermal exposure. Erythema is evident within 15 to 30 minutes, and blisters manifest within several hours. Blisters typically begin small, in the center of the erythema, and expand to include an entire inflamed area (unlike the "string of pearls" pattern seen with mustard).

Phosgene oxime is not a "true vesicant" because it does not produce fluid-filled blisters; instead it produces solid lesions that resemble urticaria. Pain is immediate (within seconds). There has not been any verified battlefield use.

Riot control agents (CN and CS) can be disseminated as smoke generated from a grenade or as a powder or liquid. Of the two, CN is slightly more toxic than CS. They both have respiratory tract, dermal, and ophthalmic effects. Both are primary skin irritants that cause prickling and burning within minutes of exposure, accompanied or followed by erythema. They can cause contact dermatitis. Vesication is more likely with CN than with CS, and CN is a more potent skin sensitizer than CS. Frequent exposure increases the likelihood of allergic dermatitis. The use of large amounts of CN in a confined space can cause serious injury or death.

Treatment

The treatment for vesicant exposure includes decontamination and supportive care. For mustard exposure, decontamination must occur within the first few minutes to effectively decrease or prevent tissue damage. By the time the patient arrives at an emergency department, decontamination is useful only to prevent secondary exposure of treating medical personnel. Patients should be hospitalized if there is a large area of erythema, painful or blinding eye lesion, or respiratory injury with productive cough and dyspnea. The skin can take months to heal. Patients should be advised to keep the lesions clean and use calamine lotion or a similar topical agent. Large blisters should be unroofed and irrigated, and topical antibiotics should be applied. These patients will be in great pain, so emergency physicians should be liberal in the use of systemic analgesics. There also can be a need for systemic antipruritics. The eyes should be treated with irrigation, topical antibiotics, and a mydriatic. Gastrointestinal side effects of nausea and vomiting can be controlled with antiemetics. For severe, nonproductive cough, the patient can be treated with antitussives and demulcents. If there are severe pulmonary signs, the patient should be intubated early. Because effects can be delayed, close followup evaluation is advised. Patients also can develop long-term effects such as hypopigmentation or hyperpigmentation, leukopenia, or tracheal and bronchial stenosis.

Critical Decision: *What is the antidote for patients exposed to arsenicals?*

Patients exposed to arsenicals (Lewisite) must be decontaminated. To reduce systemic effects, they also should receive the antidote, dimercaprol (BAL), as soon as possible as an IM injection. In addition to the toxicity of arsenicals, the patient can experience side effects from the dimercaprol such as hypertension and tachycardia. Treatment of the skin, eyes, and airway is guided by the same principles as for mustard exposure. The person exposed to arsenicals should be instructed that there could be a need to follow up for signs of possible long-term effects such as chronic respiratory disease or eye injuries.

There is no antidote to phosgene oxime. The major treatment is immediate decontamination. Any necrotic lesions that develop should be cleaned, and efforts should be made to avoid infection. The physician should watch for pulmonary lesions and the development of pulmonary edema.

Critical Decisions: *What is the best method for decontaminating patients exposed to riot control agents?*

The effects of riot control agents (CN and CS) are usually self-limiting. It is rare for complications to develop on the skin, eyes, or airway. Suggestions have been made for special decontamination solutions (eg, alkaline solution), because soap and water decontamination could temporarily increase symptoms. On a practical level, copious showering with water will suffice in nearly all cases. The skin rash should be treated with a topical steroid for dermatitis, topical antibiotics for skin lesions including vesicles, and moist dressings. Conjunctivitis should be treated with copious flushing. Respiratory symptoms (eg, dyspnea, coughing, chest discomfort) may not manifest for 12 to 24 hours, so patients

should be instructed to contact their treating physicians if these symptoms develop. Patients may suffer allergic reactions with wheezing or even stridor secondary to riot control agent exposure. There also can be transient hypertension.

Biological Agents

Biological agents of WMD origin with dermal effects and symptoms include: 1) bacterial agents (eg, *Bacillus anthracis* [anthrax] and plague), 2) viral agents (eg, Poxviridae [smallpox, variola]), and 3) toxins (eg, trichothecene toxin [T-2 mycotoxin]).

B. anthracis exists in soil as spores and infects animals worldwide. Human cases are rare. Prior to the anthrax attacks in the fall of 2001, cases were reported to occur at the rate of approximately 1 per year, and most were cutaneous. The incubation period is 1 to 5 days postinoculation. A small papule progresses to a vesicle (1 to 2 cm) in 1 to 2 days. It ruptures and leaves a necrotic ulcer that can be surrounded by edema. The lesion can be painless. The edema can be massive, covering the face and limbs and is known as "malignant edema." Patients can present with fever, malaise, or headache. There is an ulcer at the base with a black eschar that lasts 2 to 3 weeks, then separates, and leaves scaring (Figure 2). The mortality rate with treatment is less than 1% unless septicemia develops, which is rare.

Plague is an infection that humans acquire from an infected flea, animal, or another person. In the United States, relatively few cases per year have been reported since 1990, with most occurring or acquired in the western states between April and November. Plague can be bubonic, septicemic, or pneumonic, although most cases in the United States are bubonic. Patients can have sudden chills, fever, and headache, followed several hours later by nausea and vomiting. Altered mentation can be present. Lymph nodes will be erythematous, tender, and swollen. Buboes manifest 1 to 8 days after incubation; about 6 to 8 hours following the onset of other symptoms. The most common location for buboes is the femoral region, but they also can occur in the inguinal, axillary, and cervical areas, depending on the site of inoculation (Figure 3). The buboes are extremely painful. If untreated, septicemia will develop in 2 to 6 days. If secondary pneumonic plague develops, airborne transmission can occur. Therefore, patients with bubonic plague must be placed in isolation for the first 48 hours. Patients can develop bladder distention, confusion, anxiety, anuria, tachycardia, hypotension, and leukocytosis.

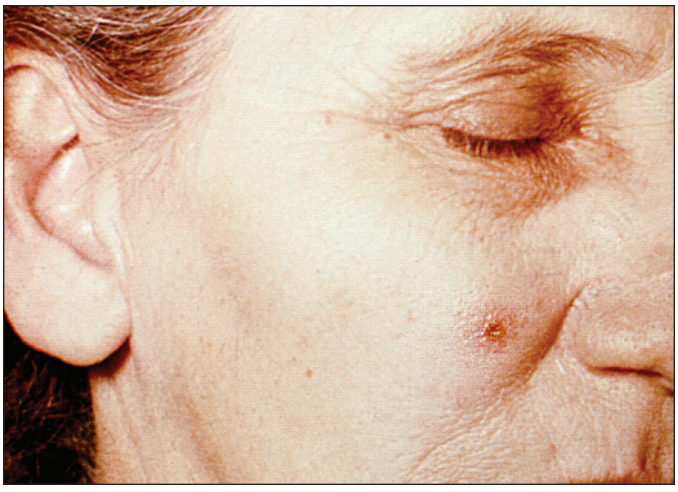
Critical Decision: *How do you identify the patient with smallpox?*

A viral agent of great concern is smallpox (Poxviridae or variola poxvirus). Variola is a highly stable virus that retains its infectivity for long periods outside a host. The incubation period averages 12 days. The virus travels from the upper or lower respiratory tract to the regional lymph nodes, giving rise to a viremia, followed by a rash. In the acute phase, patients will experience malaise, fever, rigors, vomiting, headache, and backache. The patient can experience delirium. Following infection via the respiratory route, the virus replicates in local lymph nodes. From there, the virus is disseminated to lymph tissues, spleen, liver, bone, and lung. This is accompanied by development of an erythematous rash on the face, hands, and forearms occurring over 2 to 3 days following the beginning of the febrile illness. The eruptions spread from legs to trunk. Lesions progress from macules to papules to pustular vesicles and are more abundant on the extremities and face (Figure 4). This centrifugal distribution is a diagnostic feature differentiating smallpox from varicella (chickenpox). The pustule rash forms scabs 8 to 14 days postonset and leaves depressed scars. The virus can be present in scabs throughout healing.

The rash of smallpox must be differentiated from chickenpox. An emergency physician frequently sees cases of chickenpox. Smallpox has been eradicated, but there are two known repositories of the live virus (in the United States and in Russia) and possibly some nonauthorized stores of the

Figure 1. Mustard gas. Symptoms of exposure to mustard gas begin within 4 to 8 hours as erythema and can progress, 2 to 18 hours later, to small vesicles with surrounding erythema ("string of pearls"). Over the following days, bullae can form that are dome shaped, thin walled, superficial, translucent, yellowish, and 0.5 to 5 cm or larger in diameter. Severe exposure causes third-degree burns with a central zone of coagulation necrosis and peripheral blisters.

Figure 2. Anthrax, 4th day. The anthrax lesion is a small papule that progresses to a vesicle (1 to 2 cm) in 1 to 2 days. It then ruptures and leaves a necrotic ulcer that may be surrounded by edema. The lesion may be painless.



virus that could be used as a WMD. There are a number of characteristics that differentiate smallpox from chickenpox (Table 1). The patient with smallpox presents with a toxic illness with systemic symptoms; the patient with chickenpox does not generally feel or appear seriously ill. The smallpox rash is erythematous and progresses to pustular vesicles; chickenpox develops into superficial vesicles. Smallpox begins on the face and spreads to the extremities; chickenpox spreads to the trunk. Most patients with smallpox have lesions on the palms or soles of the feet; patients with chickenpox rarely have lesions on the palms or soles of the feet. Finally, the lesions of smallpox all tend to be at the same stage of development, whereas the rash of chickenpox is usually present in several forms at the same time (Figure 5).

The toxin of most concern is trichothecene toxin. It can be delivered as dust, droplets, aerosols, smoke, or "yellow rain." It has excellent potential for weaponization. It is 400-fold more potent than mustard. The most common symptoms of exposure are vomiting, diarrhea, and bleeding. Dermal exposure causes a red, tender, swollen, painful, pruritic rash. There can be small or large vesicles, bullae, petechiae, and ecchymosis. Black, leathery areas of necrosis can be seen (Figure 6).

Treatment

Critical Decisions: *Which patients exposed to biological agents of weapons of mass destruction require isolation?*

Treatment of patients exposed to biological agents of WMD origin with dermal effects and symptoms can include antibiotics and public health measures (eg, isolation) depending on the biological agent used.

Antibiotics are an important initial therapy for anthrax. Although more potent antibiotics are often prescribed,

Figure 3. Plague inguinal bubo. Plague infection causes tenderness and swelling nodes regional to the source of infection (flea bite). These nodes become firm and matted, with surrounding edema and hemorrhage (bubo). Suppuration and drainage can occur in 1 to 2 weeks.

Figure 4. Smallpox on the arm, day 4. Smallpox lesions are pustules located on the face and extremities and are in the same stage of development in the same locations at the same time (either macules, papules, or pustules).

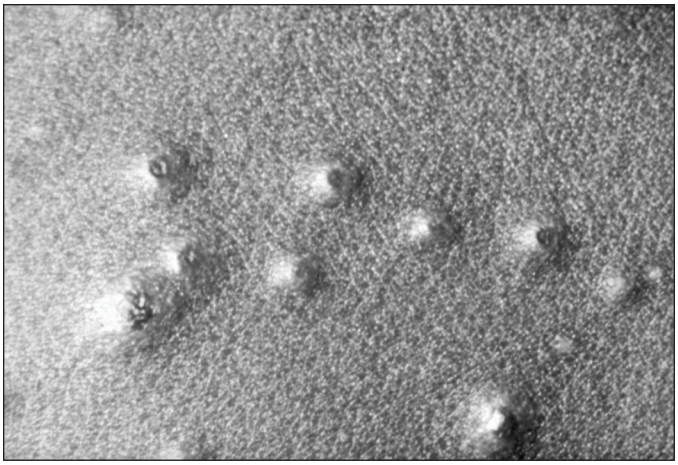


Figure 5. Chickenpox. Chickenpox lesions are superficial vesicles located on the face and truck. The lesions are in various stages of development in the same location at the same time (macules, papules, and vesicles).

Figure 6. Trichothecene. Dermal exposure to trichothecene causes a red, tender, swollen, painful, pruritic rash that can develop into small or large vesicles, bullae, petechiae, and ecchymosis. Severe exposure causes black, leathery areas of necrosis.

assuming a nongenetically engineered, antibiotic-resistant strain, the patient with cutaneous anthrax without toxicity or systemic symptoms can be treated with oral penicillin. If there is evidence of spreading infection or systemic infection, IV therapy with high-dose penicillin (2 million units every 6 hours) is indicated. Effective therapy will reduce edema and systemic symptoms but will not change the evolution of skin lesions. Treatment should be continued for 7 to 10 days. Other effective antibiotics include tetracycline, erythromycin, and ciprofloxacin. Although the inhalation and gastrointestinal forms of anthrax are not communicable, cutaneous anthrax can rarely be spread by human-to-human transmission.

Antibiotics also are important in the initial treatment for plague. The diagnosis should be confirmed with fluorescent antibody stains of sputum or tissue. Patients must be isolated for the first 48 hours. Blood (and bubo fluid) precautions are necessary. If there is no evidence of pneumonia or draining lesions at 48 hours, the patient can be taken out of isolation. Since 1948, streptomycin has been the treatment of choice for plague and is given as 30 mg/kg/day in two divided doses for 10 days. For mild cases, it can be given by mouth. However, many hospital formularies do not currently contain streptomycin. Gentamicin can be used as an alternative. If patients are treated with antibiotics, their buboes typically recede in 10 to 14 days and do not require drainage. Without treatment, the mortality rate for bubonic plague approaches 60%.

Viral biological agents of WMD origin with dermal effects and symptoms are not effectively treated with antibiotics. The most serious of the viral agents discussed here is the Poxviridae. Any confirmed case requires an immediate report to public health and law enforcement authorities. Infected individuals must be strictly quarantined, and all contacts must be placed in respiratory isolation for 17 days. Smallpox is transmitted person-to-person. Persons are probably immune if they have been vaccinated within the past 3 years and have had a verified clinical take (ie, vesicle formation with surrounding erythema and induration). Immunoprophylaxis (vaccination) is highly effective and recommended for those having contact with an infected patient.

The major toxin that may be used as a weapon of mass destruction is trichothecene mycotoxin. Decontamination is of primary importance. The eyes should be irrigated with isotonic solution. The skin can be treated with calamine or similar lotion. If there are respiratory symptoms, the patient should be treated with steam inhalation and a cough suppressant. If patients exhibit serious symptoms, they should be referred to a pulmonary specialist.

Summary and Case Resolution

The patient in the first presentation was exposed to tear gas. Because previous exposures had sensitized him, he was having an allergic reaction to the gas and experiencing urticaria and laryngeal edema with stridor. The emergency physician immediately treated him with subcutaneous epinephrine, IV steroids, and antihistamines. He improved within 3 hours and was released on oral steroids and antihistamines.

The patient in the second presentation exhibited classic symptoms of smallpox. The emergency physician immediately quarantined the patient and contacted public health officials to secure their help in finding and isolating (for 17 days) all those who had been in direct contact with him. Persons who had had any contact with the patient were vac-

Table 1. Differentiating smallpox from chickenpox

Evaluation	Smallpox	Chickenpox
History		
Prodrome	Ill for 1 to 4 days before developing the rash; become febrile and toxic with systemic complaints (prostration, headache, backache, chills, vomiting)	Usually not ill (especially children); if prodromal symptoms are present, they only last for 1 to 2 days and are very mild with low-grade fever
Severity of illness	Very ill from the start of the illness, often toxic	Usually not severely ill unless complications develop
Exposure history	May not be known to patient	Majority of patients remember exposure to person with chickenpox or herpes zoster
Physical examination		
Lesion description	Hard, circumscribed pustules	Superficial vesicles with surrounding erythema
Distribution of skin lesions	On face and distal extremities	On face and trunk
Involvement of palms or soles	Palms and soles involved	Palms and soles not involved
Development of lesions	Slow development with each stage taking 1 to 2 days; lesions at the same stage of development in every portion of body	Rapid development of disease taking only 1 day; lesions in multiple stages of development in each portion of body

Pearls and Pitfalls

- The best antidote for patients exposed to arsenicals (eg, Lewisite) is dimercaprol (BAL), which should be administered after the patient is decontaminated.
- Soap and water may temporarily increase symptoms (eg, a burning sensation) if used to decontaminate patients exposed to riot control agents. Ideally, these patients should be decontaminated with an alkaline solution.
- Patients with smallpox present with a toxic febrile illness with systemic symptoms (prostration, headache, backache, chills, and vomiting); patients with chickenpox present with a mild illness.
- The rash of smallpox is centrifugal, beginning as an erythematous rash on the face, hands, and forearms that later may spread to the trunk. The lesions progress from macules to papules to pustular vesicles. The rash of chickenpox is centripetal, concentrated on the trunk, with few lesions on the extremities and in multiple stages simultaneously.
- Most patients with smallpox have lesions on the palms of their hands or soles of their feet; most patients with chickenpox do not.
- Patients exposed to plague should be isolated for the first 48 hours.

cinated unless they could verify that they had had a vaccination with a verified clinical take (vesicle formation with surrounding erythema and induration) in the past 3 years.

Emergency departments must be prepared to receive patients exposed to chemical and biological agents of WMD origin. Chemical agents with dermal implications include vesicants (mustard, arsenics, and phosgene oxime) and riot control agents (CN and CS). Biological agents with dermal implications include bacteria (cutaneous anthrax, bubonic plague), viruses (smallpox), and toxins (T-2 mycotoxin). Emergency department personnel must be trained and equipped for decontamination (for those exposed to chemical agents) and isolation (for those exposed to some biological agents). Emergency departments must be well integrated into the local community emergency management plan and conversant with local public health reporting structures.

Suggested Reading

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Disclaimer

The views expressed in this article do not necessarily represent the views of the Department of Veterans Affairs or of the United States Government.

Mass Casualty Management: A Coordinated Response

Objectives

On completion of this lesson, you should be able to:

1. Identify the major components that comprise the medical response to a mass casualty incident.
2. Describe the actions that should be performed by the responding emergency medical services agency.
3. In addition to physicians and nurses, list the additional personnel and services that will be needed in a hospital during a mass casualty incident response.
4. Describe the importance of critical incident stress management (CISM) after a mass casualty incident.
5. Describe the advantages and disadvantages of having a physician respond to the disaster scene.
6. List the steps necessary to respond to an incident that potentially involves a weapon of mass destruction.

Critical Decisions

- What are the components of the medical response to a mass casualty incident?
- What actions should be taken in the field to manage a mass casualty incident?
- Should a physician be sent to the disaster scene?
- Who should be called to prepare the hospital to receive casualties?
- Besides health care providers and support services, who else should be called to assist, and are there other preparations that should be made?
- What is the Incident Command System and how does it apply to hospitals?
- What additional measures are needed if the incident involves a weapon of mass destruction such as a chemical or biologic release?
- What further steps should be taken after casualties have been dealt with and the incident appears to be over?

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Although events of the recent past have focused attention on it, the medical response to a mass casualty incident has always been an important and integral component of the daily practice of emergency medicine. For some emergency physicians, involvement in such incidents will occur too often in the course of their careers, while many others will never be involved with a multipatient disaster. For some emergency physicians, primarily those involved with emergency medical services (EMS), participation in a mass casualty incident will begin with the field response; however, most emergency physicians will become involved as receiving physicians in emergency departments.

The successful management of a mass casualty incident requires that emergency physicians consider the various components of a disaster response needed to optimally manage casualties; prepare and test a plan that addresses the components, beginning with the field care and culminating with the recovery phase; and then implement the actions necessary to optimize the chances for survival of victims from such an occurrence, regardless of the etiology of the event.

Case Presentation

Paramedics from an ambulance that has just transported a patient to your emergency department report that they must immediately leave because they have just been dispatched to a reported train derailment with an associated explosion. They have been told that there are numerous casualties.

Critical Decision: *What are the components of the medical response to a mass casualty incident?*

When planning for or implementing the medical response to a disaster or mass casualty incident, there are three major components that comprise the medical response. Each of these components is made up of a series of decisions and actions that are integral to an effective overall medical effort. Each component flows into the next and is responsible for initiating the disaster response of the succeeding element.

These components are: the out-of-hospital response; the notification and response of the medical community at large; and the preparations and response of each individual receiving hospital (Table 1).

In most cases, the initial notice of a mass casualty incident will be received at an emergency response dispatch center (eg, 9-1-1 call center). Police, fire department, and EMS response to the disaster scene will follow.

The police department is responsible for scene security, establishing a perimeter border, and crowd and on-looker control, as well as the investigation and evidence collection at what may be a crime scene, if the incident resulted from criminal action. The fire department is responsible for overall scene safety, fire suppression, and hazard assessment, including structural evaluation of involved buildings and assessment of chemical contamination potential.

The out-of-hospital medical response is generally the responsibility of the local EMS agency. The first arriving medical responders have the important task of recognizing and defining the nature and magnitude of the incident from a medical perspective and activating the next two components of the medical response, if warranted. If the number of casualties exceeds the usually available resources (field or hospital), the EMS system must alert the medical community that a mass casualty incident has occurred, activating the second major component of the medical response to a mass casualty incident. This second component is made up of the receiving facilities to which casualties will be transported by the first component, the EMS system. Finally, activation of component two, the receiving medical community, will call for implementation of each individual hospital's disaster response plan (component three).

Critical Decision: *What actions should be performed in the field to manage a mass casualty incident?*

As was mentioned previously, the first medical responders to the scene of a potential mass casualty incident have a critically important task to perform, and this task deviates from the usual protocol of finding the most critically ill or injured patients and initiating life-saving care. Instead, the responder must stand back and assess the overall situation.[1] The responder must, to the extent possible, answer a number of questions:

1. What is the nature of the incident?

2. Approximately how many victims are there?
3. What resources are going to be needed at the scene for extrication, treatment, and transport of victims?
4. Are there additional special needs such as personal protective equipment (PPE), decontamination equipment, and heavy extrication equipment, including bulldozers and cranes?

This information must be transmitted to the dispatch center where the process of acquiring and dispatching the needed resources to the scene will occur.

It is at this point that the EMS provider responsible for managing the scene must make the critical decision about the need for alerting and activating the second component—the receiving medical community. Ideally, every EMS system should have a communication mechanism in place that can be used to notify receiving hospitals that a mass casualty incident has occurred and that preparations should be made to receive victims. In those communities with one hospital, activation of the medical community is the same as activating the individual hospital. However, in those communities with multiple hospitals, activating the medical community should be tailored to the magnitude of the event. In the event of a relatively small mass casualty incident, it might be necessary to alert only trauma centers, whereas a more destructive incident could necessitate notification of every hospital in the region or even more distant hospitals.

After transmitting the needed information to dispatch, as described earlier, medical responders at the scene can begin the process of triage and transport. Triaging patients provides a mechanism for prioritizing patients for treatment and transportation. Patients can be grouped according to triage category, allowing subsequent responders and care providers to quickly and easily identify those in need of immediate attention. The majority of EMS systems use a four-category triage system:

I. red—critical (immediate care)
II. yellow—moderate
III. green—minor
IV. black—dead or mortally wounded

Here again, it is important for responders to remember that the usual protocols no longer apply. The usual policy of providing and performing virtually every available medical intervention, even for patients who are likely mortally wounded, does not apply in a mass casualty situation, at least early in the event when personnel and resources are limited. Instead, patients who otherwise would have been intubated or bagged or who would have received CPR will be declared dead or expectant.[2] Initial care is limited to assessing criticality, manually opening the airway, treating tension pneumothorax, and controlling hemorrhage.[3]

A commonly used system that combines both triage and immediate intervention is known as the Modified Simple Triage and Rapid Treatment (START) system.[1] The prehospital provider first looks to see if a victim is breathing. If the answer is no, the airway is opened, and the patient is evaluated to see if breathing resumes; if so, the patient is assigned to class I (immediate). If breathing does not resume, the patient is considered dead or dying (class IV). If, on the initial breathing check, the patient is breathing and the respirations are 30 or more per minute, the patient is again assigned to class I. If the patient is breathing less than 30 times per minute, the next step is to assess the radial pulse. If no pulse is palpable, any external bleeding should be controlled and the patient categorized as class I. If a pulse is palpable, the level of consciousness is evaluated. If the patient does not follow commands, the patient is once again assigned to class I. If commands are followed, the patient is assigned to a delayed category (II or III).

The over-riding treatment philosophy in a mass casualty incident (where, by definition, the number of victims exceeds the available resources) is to provide the most care to the most people who are likely to survive.[1] This means that emergency medical providers must make difficult decisions about the potential survival of casualties and possibly withhold or provide minimal care for those patients with no or little chance of surviving in order to maximize the opportunity for other patients to live.

Critical Decision: *Should a physician be sent to the scene of a mass casualty incident?*

This is an issue that always generates a lot of discussion with little data to support any particular position. What does seem clear, however, is that physicians should not be sent to the scene unless they are trained, prepared, and equipped to deal with the needs at that particular scene. As a general statement, most people do best what they do every day; in the case of physicians, what they do every day is provide definitive care for patients in the hospital setting.

Having said that, there are times when it can be beneficial for a physician knowledgeable and trained in mass casualty management to be present on the scene. Specific indications for the dispatch of physicians to a disaster include:

1. The need to perform procedures that are not typically a component of EMS provider practice (eg, the need to perform an amputation in order to extricate a victim)
2. The need to provide on-scene medical care for a prolonged period of time because the number of victims exceeds the transportation resources
3. The need to perform a higher, more critical level of patient triage, particularly to help define and differentiate those with little likelihood of survival from those who might survive, given the available resources at the scene and in the hospitals.

Table 1. Steps in mass casualty incident management

Steps	Details
1. 9-1-1 call	EMS notification and activation
2. EMS agency response	Scene response Incident magnitude assessment Patient triage Patient transport
3. Notification and activation of medical community	Notification of receiving facilities
4. Hospital response and activation	Emergency department Alternative treatment sites Specialists (based on nature of incident) In-patient beds (ward, ICU) Nursing Laboratory Administration Central supply Food services Psychiatry, social services Clergy Medical examiner, coroner, morgue, pathology
5. Agency stand-down	CISM

Critical Decision: *Once EMS notifies the medical community and each hospital prepares to receive casualties, who should be called to get everything ready?*

In most EMS systems, the EMS agency will notify the emergency departments of receiving hospitals that an incident has occurred and instruct them to initiate the hospital disaster plan. Based on the nature of the event, medical providers of various types and specialties will be needed and will have to be contacted. Incidents involving traumatic injury will require additional emergency physicians, surgeons, anesthesiologists, orthopedists, neurosurgeons, and possibly other specialists such as ophthalmologists and otolaryngologists. Incidents involving chemical or biologic agents will require not only emergency physicians but also toxicologists, internists, and infectious disease and public health specialists.

Nursing services will need to call in additional nurses, nursing assistants, and technicians to augment staff in the emergency department, ICUs, wards, and operating rooms. Medical support services also must be notified in order to prepare to manage the increase in patients needing care. These services include radiology (both physicians and technologists), laboratory, and central supply. The hospital blood bank should be called to assess the supply of blood and blood products and to acquire additional units if indicated.

Critical Decision: *Besides health care providers and support services, who else should be called to assist, and are there other preparations that should be made?*

Perhaps first on the list of other people to call is the hospital administrator or chief executive officer. The hospital administrative staff needs to be notified and involved; they will be responsible for paying for all of the staff, equipment, and supplies that are being called for and may be helpful in making decisions about hospital services.

Public relations or information personnel also should be notified.[4] There will be a significantly increased demand from the news media for information, as well as requests for interviews with medical providers, victims, and family members. Depending on the nature of the event, it can be necessary to issue press releases or hold formal press conferences to keep the public informed about medical concerns or issues. This is particularly important if the incident involves a weapon of mass effect, as recently occurred with the anthrax release in the United States.

Social service personnel, psychiatrists and other mental health workers, and clergy also should be notified. The need for counseling, crisis intervention, and religious support will be dramatically increased. In addition to inducing psychological trauma in victims and their families, mass casualty incidents affect the mental well-being of the community at large. Significant numbers of patients, often referred to as the "worried well," seek medical attention, counseling, and psychological support.

To handle an expected increased number of deaths, pathology services, the morgue, coroner's office, and medical examiner facilities also should be notified.

Another important consideration is space for patients. The emergency department should be cleared of noncritical patients and arrangements made to care for these and other routine walk-in cases elsewhere in the facility. Additional patient care areas should be identified where victims and other critical emergencies can be treated in the event that all available space in the emergency department is used and the patient care capacity is exceeded. Besides emergency department bed space, room will be needed in critical care units and in the wards. Someone on the hospital medical staff, perhaps the chief of the medical staff or chief of service, must be tasked with identifying patients who can be moved out of the ICU to a step-down or ward bed as well as patients who can be discharged from the hospital earlier than planned.

Incidents involving biologic agents pose special considerations for patient bed space. Many of the biologic agents used as weapons are transmissible; therefore, cohorting of patients in the hospital is an important step in minimizing the risk of person-to-person spread. Creating a ward or floor devoted to caring for infected patients can help prevent disease transmission. This cohorting of patients is appropriate for agents such as pneumonic plague, smallpox, and the viral hemorrhagic fevers.

Consideration also must be given to rotating staff and providing time and a place for health care providers to rest. Arrangements must be made for feeding the increased staff as well as the additional patients. Cafeteria workers may need to be called in, and the kitchens opened during normally closed hours to provide food and drink to staff.

Critical Decision: *What is the Incident Command System and how does it apply to hospitals?*

The Incident Command System (ICS) was first developed for the fire service in an effort to provide a common organizational structure to coordinate the many components required for responding to and successfully managing a large incident. This organizational scheme has subsequently been modified for use in the hospital setting in the event of a mass casualty incident.[5] The Hospital Emergency Incident Command System (HEICS) has the advantage of bringing an organized, structured, emergency management system with defined responsibilities and reporting channels to what is often a confused and disorganized effort. Under this system, there is an overall incident commander. Reporting to this incident commander are four section chiefs, each responsible for one of the following areas: logistics, operations, planning, and finance. Each of these sections is further subdivided into various subsections to better assign and distribute the workload. Depending on the incident, each subsection may be assigned a separate subsection leader, or a section chief may perform all of the subfunction duties. The HEICS approach thus offers a predefined structure for incident response and management that can be contracted or expanded as needed, depending on the needs at any given moment in any given incident.

Incidents Involving Weapons of Mass Effect

It is probably appropriate to talk about the nomenclature. Biologic, chemical, and radiologic weapons are called "weapons of mass destruction" but would be better named "weapons of mass effect," because early recognition and rapid treatment can minimize mortality.

It may be obvious that a weapon of mass effect has been used, or it may be extremely difficult to determine, depending on the agent used.[6] Key to recognizing an incident involving a weapon of mass effect is understanding the clinical syndrome produced by all of the various agents and the time course for presentation. An attack involving a chemical weapon will be manifested by a large number of patients who present with similar complaints, symptoms, and findings over a relatively short period of time—usually minutes to hours after the exposure. In most cases, the effect of a chemical weapon will be geographically localized to a relatively small area. In contrast to the chemical agents, an incident resulting from a biologic release or radiologic exposure will generally unfold over several days or more as exposed individuals gradually become ill enough to seek medical attention.[7] In addition, these patients may present over a wide geographic area, because travel may have occurred between the time of exposure and the onset of clinical illness. Important clues to a biologic incident include illness that is unusual or unexpected for the time of year or locale; unexpected deaths of birds, animals, and patients, often beginning with patients who are immunocompromised; and large numbers of patients presenting with similar symptoms that progress to serious, life-threatening illnesses.[8]

Critical Decision: *What additional measures are needed if the incident involves a weapon of mass effect such as a chemical or biologic release?*

Additional preparations and notifications must be made in the event of an incident involving a weapon of mass effect. First and foremost is the need to protect the integrity and function of the hospital.[9] In order to accomplish this, lockdown of at least the emergency department, if not the entire hospital, should be ordered. Patients should be met outside the emergency department, the risk of contamination assessed, and the need for decontamination determined. No patient should be permitted to enter the facility until the contamination risk has been determined and appropriate decontamination has taken place.

Personnel performing the contamination risk assessment must use appropriate PPE (Table 2). For most cases involving possible biologic agents, standard droplet/airborne precautions will suffice (Level D). If chemical agents are suspected, a higher level of protection must be used, usually level B or C protection.

If chemical poisoning is suspected, patients will require decontamination outside the emergency department. Although many suggestions have been made for special decontamination solutions, in fact, copious showering with water will suffice in virtually all cases. Ideally, contaminated effluent should be captured in a runoff storage tank; however, dilution of the runoff without containment will usually minimize any subsequent hazard.

Arrangements must be made to obtain necessary antibiotics or antidotes and, for incidents involving many agents, additional ventilators. Many local and state public health departments, emergency medical response systems, and hospitals have developed plans for acquiring and stockpiling needed medications. Unfortunately, local supplies can prove inadequate in the event of a large exposure. In an effort to provide for the needs of large numbers of patients, national stockpiles of antibiotics, antidotes, and ventilators have been prepared and can be transported throughout the nation if necessary.[10] Personnel in all public health departments, EMS agencies, and hospitals should know how to initiate a request for these supplies in the event of a weapon of mass effect incident. Ideally, once these supplies are received, a preexisting plan will be implemented to distribute the medications to patients, family members, medical care providers, and at-risk members of the public.

Notification of appropriate authorities must be made on suspicion or recognition of a weapon of mass destruction incident. These authorities include local and state health departments; law enforcement agencies, both local and federal, such as the FBI; and appropriate governmental representatives such as the mayor and governor through whom additional resources such as the National Pharmaceutical Stockpile can be requested.

Finally, weapons of mass effect incidents that have already occurred worldwide have resulted in large numbers of psychologic casualties, the so-called "worried well," who seek medical attention, often in very large numbers. Thus, a comprehensive plan to deal with the mental health needs of this group of patients also is necessary.[11]

Critical Decision: *What further steps should be taken after victims have been dealt with and the incident appears to be over?*

Just as there should be a mechanism in place for the EMS system to notify and activate hospitals when a disaster occurs, so, too, should there be a mechanism for notifying hospitals to stand down once it is evident that the incident has been managed and all victims have been transported.

A mass casualty incident has a profound effect psychologically, not only on victims, but also on the rescuers and health care workers involved. The large numbers of injuries and, possibly, deaths and the many difficult decisions that must be made combine to produce significant stress in health care providers; this stress can lead to impaired function over time. For this reason, critical incident stress management (CISM) should be considered an integral component of any disaster response. Trained CISM debriefers should be available to provide counseling to those in need, including patients, families, field providers (police officers, firefighters, and EMTs), as well as emergency department and other hospital personnel.[12]

Table 2. Levels of personal protective equipment*

Level A	This is the highest level of protection and involves the use of a fully enclosed, sealed suit that has positive pressure internally and a completely self-contained breathing apparatus (SCBA) and is resistant to surface and vapor exposure. It is extremely difficult to provide advanced patient care in the Level A "moon suit" because of the bulk required to provide this level of protection.
Level B	This level of protection also provides protection from surface and vapor exposure but does not entail the use of internal positive pressure. It is fully enclosed and is the level often used by hospital personnel when decontaminating chemically contaminated patients.
Level C	This level of protection resists splash and vapor contamination. It is appropriate when the contaminant is known and air purifying is adequate for the agent identified.
Level D	This level of protection essentially comprises standard work clothing and offers minimal protection. This level includes standard precautions as used in hospitals.

*Personal protective equipment is the equipment used to protect field responders and hospital personnel from the effects of a potentially toxic substance such as those used as weapons of mass effect. The equipment is categorized according to the degree of protection it provides.

Summary and Case Resolution

The EMS dispatcher calls to inform you that there are approximately 100 casualties from the train wreck. As one of two hospitals in the area, you implement your disaster plan, calling in additional emergency physicians, surgeons, and nursing staff. Eight class I (critical), 13 class II (moderate), and 29 class III (walking wounded) patients are received during the next 3 hours at your hospital. Because the hospital had a disaster plan that had been regularly tested and updated, all victims were efficiently received, evaluated, and treated.

The management of a medical disaster or mass casualty incident involves the coordinated efforts of the emergency medical response system beginning with the EMTs and paramedics of the involved EMS agencies, the subsequent notification and activation of the medical community, and the internal response of each individual hospital. Ideally, a comprehensive plan that has been rigorously tested, critically evaluated, modified as indicated by the evaluation of the test, and tested again should be in place in every hospital and community.

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Pearls and Pitfalls

- Triage at a mass casualty incident differs from the usual protocol of providing life-saving care for all the most critically ill victims
- There will be a need for other personnel in addition to health care providers to be called in to the hospital in mass casualty circumstances.
- Recognize the unique additional priorities that come into play if a weapon of mass effect is involved—protection of the hospital's integrity and decontamination of victims.
- Have a mechanism in place for notifying personnel and institutions to stand down once the incident has been managed.
- All patients, families, responders, and health care providers should be afforded an opportunity to participate in CISM.

Suggested Reading

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