Symptom-Based, Algorithmic Approach for Handling the Initial Encounter with Victims of a Potential Terrorist Attack

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Abbreviations:
ACLS = Advanced Cardiac Life Support
CDC = Centers for Disease Control
CIMERC = National Bioterrorism Civilian Response Center
EMS = emergency medical services
PPE = personal protective equipment
SARS = Severe Acute Respiratory Syndrome
WMD = weapons of mass destruction

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Abstract

Objectives: This study intended to create symptom-based triage algorithms for the initial encounter with terror-attack victims. The goals of the triage algorithms include: (1) early recognition; (2) avoiding contamination; (3) early use of antidotes; (4) appropriate handling of unstable, contaminated victims; and (5) provisions of force protection. The algorithms also address industrial accidents and emerging infections, which have similar clinical presentations and risks for contamination as weapons of mass destruction (WMD).
Methods: The algorithms were developed using references from military and civilian sources. They were tested and adjusted using a series of theoretical patients from a CD-ROM chemical, biological, radiological/nuclear, and explosive victim simulator. Then, the algorithms were placed into a card format and sent to experts in relevant fields for academic review.
Results: Six inter-connected algorithms were created, described, and presented in figure form. The "attack" algorithm, for example, begins by differentiating between overt and covert attack victims (A covert attack is defined by epidemiological criteria adapted from the Centers for Disease Control and Prevention (CDC) recommendations). The attack algorithm then categorizes patients either as stable or unstable. Unstable patients flow to the "Dirty Resuscitation" algorithm, whereas, stable patients flow to the "Chemical Agent" and "Biological Agent" algorithms. The two remaining algorithms include the "Suicide Bomb/Blast/Explosion" and the "Radiation Dispersal Device" algorithms, which are inter-connected through the overt pathway in the "Attack" algorithm.
Conclusion: A civilian, symptom-based, algorithmic approach to the initial encounter with victims of terrorist attacks, industrial accidents, or emerging infections was created. Future studies will address the usability of the algorithms with theoretical cases and utility in prospective, announced and unannounced, field drills. Additionally, future studies will assess the effectiveness of teaching modalities used to reinforce the algorithmic approach.

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Introduction

History has shown that biological agents, chemical agents, and bombs are effective weapons for terrorists. History also has demonstrated that emerging infections and industrial accidents have the same potential to cause mass destruction and present with similar symptoms as terrorist threat agents. Repeated themes have surfaced in the medical management of these incidents. In regard to the Union Carbide accident (Bhopal, India, 1984) in which 6,000 people died and 80,021 were exposed to a methylisocyanate gas leak.[1] Dhara stated, "the medical system in Bhopal was severely tested by the twin factors of large numbers of injured people streaming into hospitals and

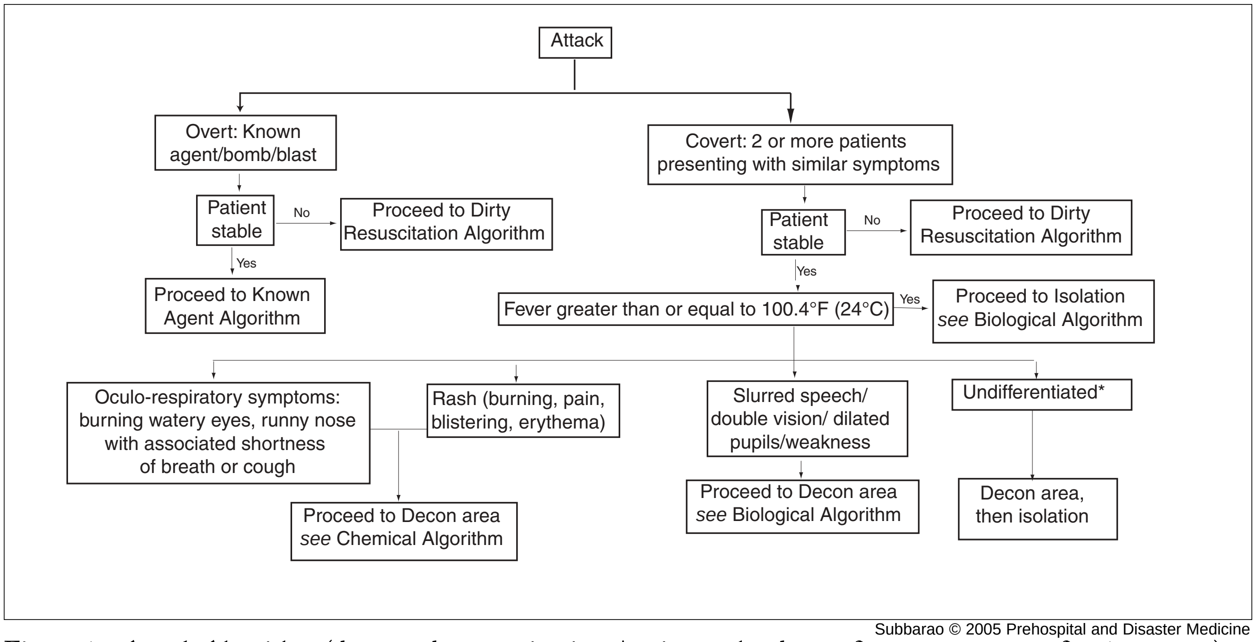

Figure 1—Attack Algorithm (decon = decontamination; *patients who do not fit any category, or fit >1 category)

the absence of a definitive protocol for treatment of the poisoning."[2] These same two factors also were noted in the Tokyo sarin attack, in which a significant number of victims were self-referred to the hospital without any definitive protocol, leading to delayed recognition and administration of the antidote.[3]

Furthermore, delayed recognition of victims of terrorist agents, industrial accidents, or emerging infections, increases the risk of secondary contamination of healthcare workers and facilities that could result in a gap in force protection. Inadequate handling of such victims has led to a high secondary contamination rate of healthcare workers. This was observed during the Severe Acute Respiratory Syndrome (SARS) outbreak in Hong Kong (85 healthcare workers were affected) and Toronto (73 healthcare workers were affected),[4] and in the sarin releases in Matsumoto and Tokyo (nine and 245 healthcare workers affected, respectively).[5,6] Secondary contamination led to the death of 50 hospital staff members taking care of an Ebola patient in the Democratic Republic of Congo, formerly known as Zaire.[7] Additionally, the risk of contamination increases when healthcare workers treat unstable, contaminated patients, particularly while performing endotracheal intubation or cardiopulmonary resuscitation. Eleven protected healthcare workers wearing N-95-like masks, accepted by Health Canada, became infected while caring for an unstable SARS patient who was endotracheally intubated in a negative pressure room.[4] Finally, five physicians treating unstable victims of the Tokyo sarin attack, including endotracheal intubation and cardiac massage, were secondarily contaminated. All five physicians were symptomatic, and three required treatment with atropine.[8]

These repeated gaps in hospital and healthcare worker preparedness demonstrate the need to create a standardized approach to managing the critical first encounter with a potential terror attack victim. Applying lessons learned from Bhopal to the current threats of terrorism, Dhara assigned priority to "train physicians and nurses to standardize clinical management of (mass poisoning) exposure victims."[2] Additionally, agencies such as the (US) Bioterrorism Civilian Medical Response Center (CIMERC) have reviewed the existing literature regarding terrorist events and agree that, "Every hospital employee needs some level of training or education regarding weapons of mass destruction (WMD) specific to his or her role in the emergency management plan." The CIMERC also suggests training emergency department staff in the use of personal protective equipment (PPE) pursuant to their roles during the decontamination process and their overall role during a WMD response.[9] The Terrorism Response Task Force of the Centers for Disease Control and Prevention (CDC), the Strategic Planning Working Group of the American College of Emergency Physicians (ACEP), and others have made similar recommendations for training providers at all levels of emergency care.[10–13]

To address the above issues, a symptom-based, algorithmic, civilian triage protocol was created to guide healthcare workers during the critical first minutes of a potential terrorist attack. The algorithms also address emerging infections and industrial accidents. They address known and unknown agents, single or multiple agents, stable and unstable patients, and adult and pediatric victims. The algorithms use initial symptoms to triage victims to isolation, ambulatory decontamination, or dirty resuscitation. The goals are: (1) early recognition; (2) avoiding contamination; (3) early use of antidotes; (4) appropriate handling of unstable, contaminated victims; and (5) provisions of force protection.

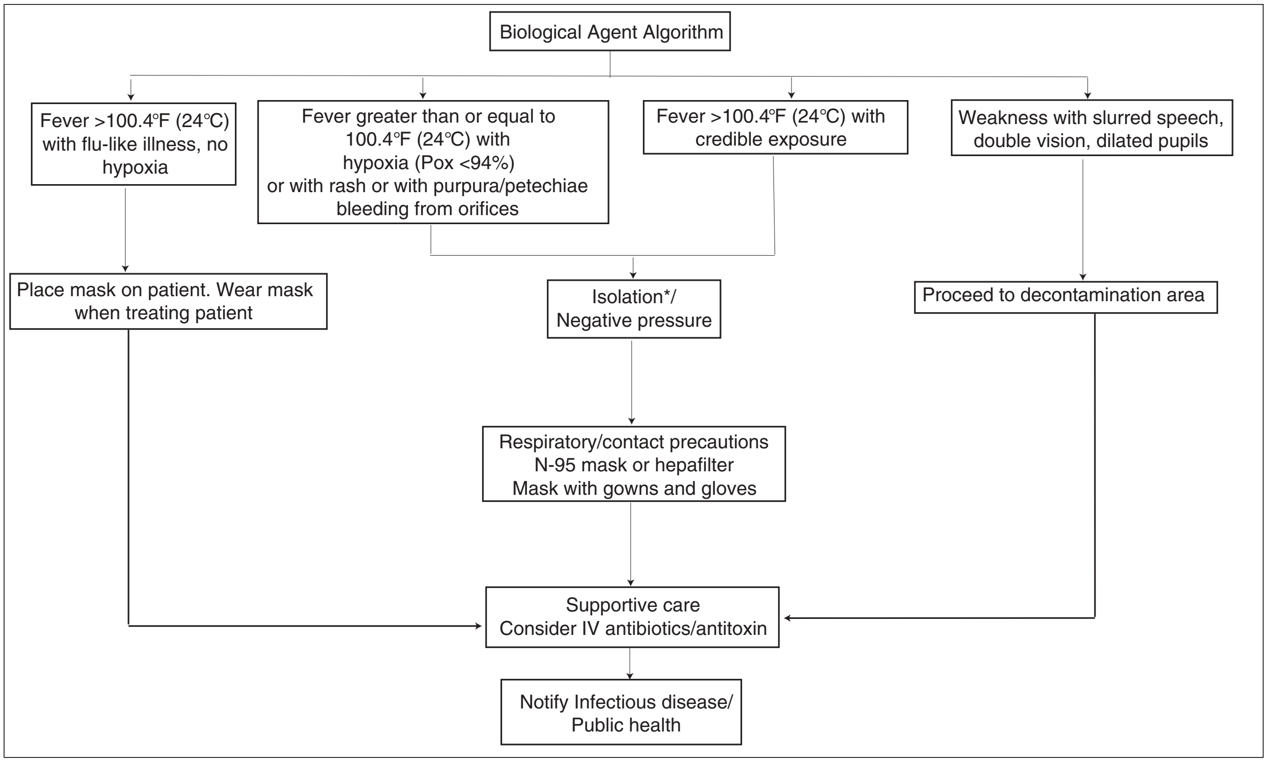

Figure 2—Biological Agent Algorithm (P_{ox} = pulse oximetry; decon = decontamination; IV = intravenous; ID = infectious disease;*Limited resource caveat plan: If negative pressure room unavailable, patient should wear surgical mask, and provider must wear N-95 mask)

Methods

The card algorithms were developed using references from military and civilian sources. The algorithms assume there has been an aerosolized release of Category-A-biological and chemical agents as the most likely mechanism that will be used for intentional dissemination of these agents.[11] The algorithms also address the more likely scenario of a simple bomb attack. An exercise was conducted, during which theoretical individual patients from a screen-based chemical, biological, radiological/nuclear, and explosive victim simulator (Bioterrorism Simulator 2002, Anesoft Corp, Issaquah, WA) were used to test the algorithms. The algorithms were adjusted during this process until all of the patients would flow through the algorithms satisfactorily.

The algorithms begin with the "Attack" algorithm card, which differentiates between overt and covert attack victims, stable and unstable stable victims, and eventually flows into one of the five remaining algorithm cards: "Dirty Resuscitation", "Chemical Agents", "Biological Agents", "Bomb/Blast", and "Radiation Dispersal Devices." Disaster management experts reviewed and commented on the algorithms to add face validity. The experts were drawn from multiple disciplines (infectious disease, trauma, toxicology, disaster medicine, emergency medical services, and military chemical weapons response) and collectively have had experience in treating SARS, hazardous material victims, and warfare casualties in Iraq. To create a usable form for each algorithm, a take-home, pocket card similar to an Advanced Cardiac Life Support (ACLS) card (©2001–2003 American Heart Association) was created.

Results

The following sections describe the development and considerations for each of the algorithms. None of the algorithms override normal operating procedures requiring isolation or the use of masks for individual, potentially infectious patients. Nor does the use of the algorithms preclude the use of other field triage systems used in mass-casualty situations.

"Attack" algorithm

To enter into the "Attack" algorithm (Figure 1), the patient must be a victim of an overt attack/agent or suspected covert attack. An overt attack is defined as known or detected agent release (e.g., Anthrax, radiation) or witnessed suicide bombing. A suspected covert attack meets epidemiological criteria adapted from the CDC's recommendations for recognition of an illness associated with an intentional release of a biological agent. These include having two or more patients present similar symptoms and an unusual pattern of: age distribution, temporal relationship, or geographic clustering.[14]

"Biological Agent" algorithm

The symptom-driven, "Biological Agent" algorithm (Figure 2) was based on combining the epidemiological approach of the CDC recommendations for recognizing a

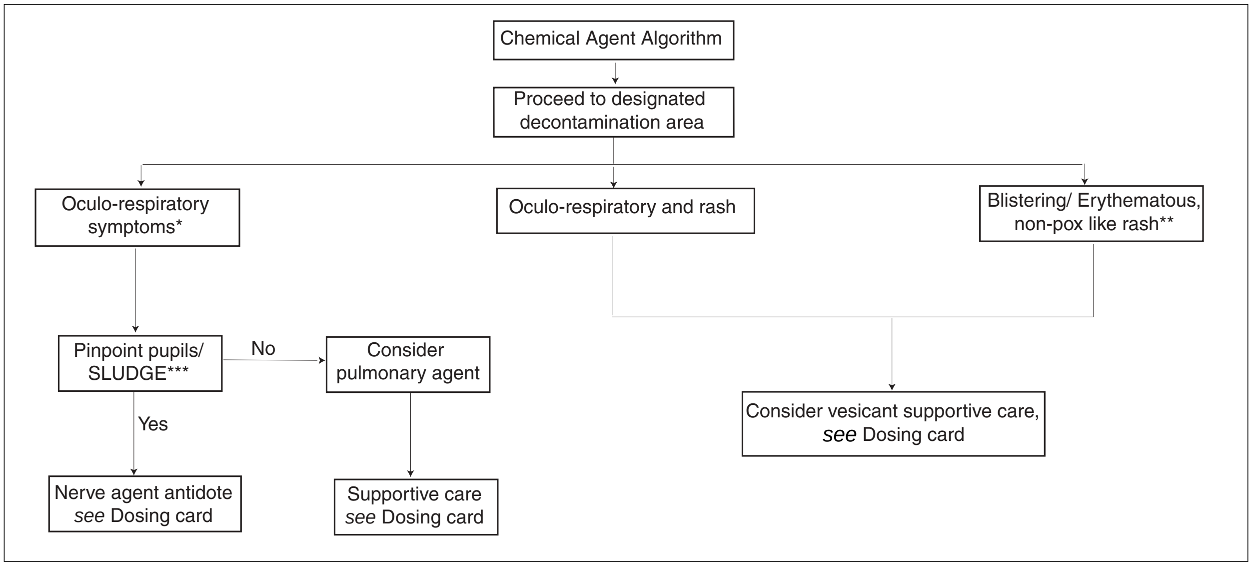

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Figure 3—Chemical Agent Algorithm (*Acute oculo-respiratory symptoms: burning, itching, watery eyes; runny nose with associated cough; shortness of breath; **Acute erythmatous blistering rash with associated skin burning and pain, non-pox like; ***SLUDGE = salivation/lacrimation/urination/defecation/gastrointestinal/emesis)

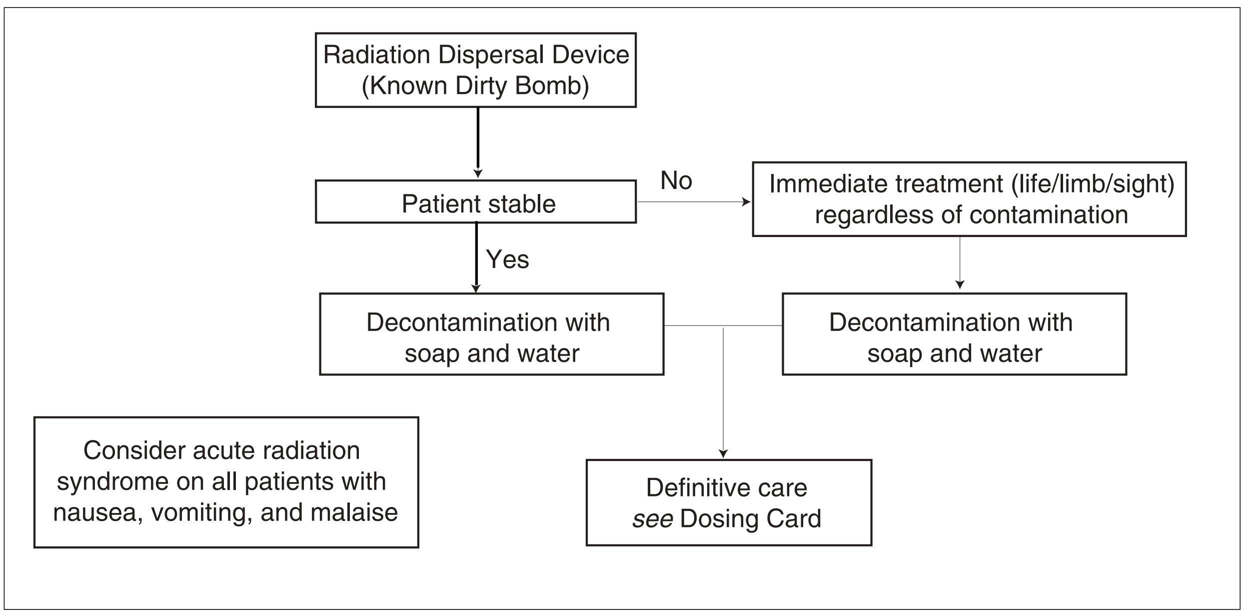

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Figure 4—Radiation Dispersal Device Algorithm

victim of a biological agent,[14] with the CDC recommendations for recognition and treatment of SARS[15] and Monkeypox.[16] The series of articles from the Civilian Working Group on Biodefense also were reviewed.[17–21] Due to the incubation period of most of the biological agents,[14] only exposure to the botulinum toxin requires decontamination.[17] Visable contamination, such as with white powder, is the other exception.

"Chemical Agent" algorithm

To create the symptom-based approach for chemical agents (Figure 3) and industrial accidents, the literature was reviewed regarding symptoms exhibited by casualties exposed to World War I mustard, phosgene, and chlorine casualties,[22] and the victims of the Union Carbide accident in Bhopal, India.[1,2] Additionally, the literature on mustard and nerve agent casualties in the Iran-Iraq War[23,24] and on sarin victims in Matsumoto and Tokyo also were reviewed.[3,5] This was combined with the CDC recommendations for recognizing illnesses related to exposure to a chemical agent.[25] The eyes, respiratory tract, and skin are the most sensitive organs following exposure to noxious chemicals. Therefore, entry into the algorithm is based on the presence of oculo-respiratory symptoms and/or rash

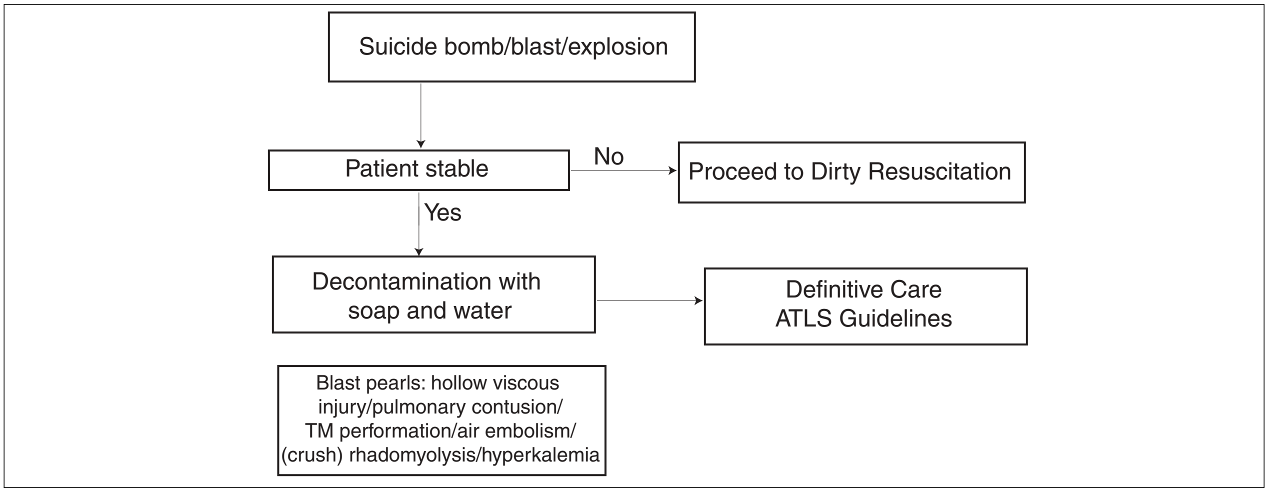

Figure 5—Suicide Bomb/Blast/Explosion Algorithm (ATLS = advanced trauma life support)

(without fever). This refers to nerve, cyanide, pulmonary, industrial, riot-control, and vesicant agents. Stable patients are triaged to ambulatory decontamination where the victims will remove their clothes and be decontaminated with soap and water.

"Radiation" algorithm
The "Radiation" algorithm (Figure 4) is based on the Military Radiation Handbook and the Medical Effects of Ionizing Radiation Course recommendations.[26] In a known radiation-only scenario, patients who have a risk for losing life, limb, or sight should be brought directly back to the trauma bay without decontamination. Stable patients should go through ambulatory decontamination to prevent secondary facility contamination. There is no identified historical case of a patient having been so irradiated that they would contaminate another person.[26]

"Bomb/Blast" algorithm
The "Bomb/Blast" algorithm (Figure 5) is based on a review of terrorist incidents,[27–32] combined with military literature of treating casualties with combined injuries.[22] Casualties with combined injuries are defined as having wounds caused by conventional weapons plus exposure to chemical, radiological, or biological agents. Only a scant amount of data exists on this topic, and little has been written about these casualties from World War I or the Iran-Iraq War.[22] The "Bomb/Blast" algorithm recommends that all patients transferred from the scene of an explosive device are presumed to have been contaminated and must be decontaminated prior to hospital entry even if they are unstable.

"Dirty Resuscitation" algorithm
The "Dirty Resuscitation" algorithm (Figure 6) was created by combining the Military Dirty Resuscitation Protocol[33] with literature on the handling of unstable patients. This includes victims of emerging infections,[4] biological agents,[14] chemical agents,[8,23,33] and combined casualties.[22] Dirty resuscitation is the management of an unstable (non-ambulatory), contaminated patient. The military protocol is performed in mission-oriented, protective-posture, Level-4 gear (which has elements of both Occupational Safety and Health Administration Level B and Level C personal protection).[34] Typically, the protocol is performed by two to four people including two first responders, one of whom is trained in airway management. Procedures allowed include airway management (combitube, laryngeal mask airway, endotracheal intubation), hemorrhage control, needle decompression of pneumothoraces, and administration of antidotes.[33] After completion of the required resuscitation measures, the patient is decontaminated using soap and water, and then is transferred to a designated treatment area. In a mass-casualty setting, the decontamination may occur at a separate station. The critical decision point in the "Dirty Resuscitation" algorithm attempts to differentiate between exposure to nerve agent vs. cyanide, because unstable victims of exposure to these agents may present similarly. Unstable biological casualties without gross contamination, need only have their clothes removed and do not need to be decontaminated.

An undifferentiated category can be reached on the "Attack" and "Dirty Resuscitation" algorithms. This category was created for patients that do not fit clearly into the "Biological Agent" or "Chemical Agent" algorithms. In this case, it is assumed the patient has been contaminated with multiple agents and will proceed to decontamination and isolation until a definitive diagnosis is determined.

It should be noted that once the algorithms were transferred to an ACLS-like card format, a section of each card was created that contains the phone numbers that can be used to reach national response agencies, such as the CDC.

Discussion
Henretig *et al* created a symptom-based, algorithmic approach to victims of bioterrorism.[35] Their approach, which

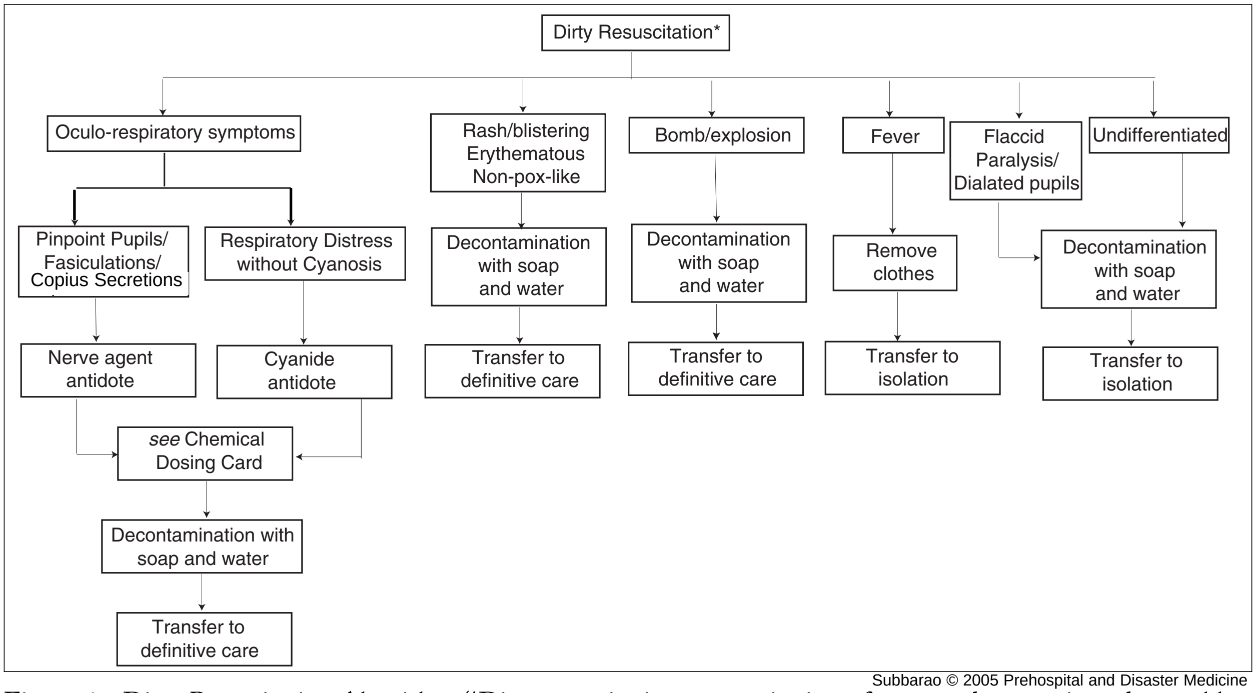

Figure 6—Dirty Resuscitation Algorithm (*Dirty resuscitation = resuscitation of suspected contaminated, unstable patient limited to airway control, hemorrhage control, needle decompression, administration of antidotes, and deontamination with soap and water)

focused on biological agents and involved the use of the chest x-ray in decision-making, was directed at a definitive diagnosis and the provision of appropriate treatment. The generated algorithm for the tasks was complex and, therefore, difficult to use in a first-contact situation in which contamination is likely to occur. The symptom-based triage algorithms do not attempt to establish a definitive diagnosis for biological agents; rather the algorithms attempt to guide resuscitation efforts and isolate appropriate patients prior to identification of a definitive diagnosis. The algorithms are simple, have a broad scope, and are intended for the first-contact provider with only limited physical examination and a partial set of vital signs available.

One reviewer commented on the need to address cyanide exposure in the stable, chemical patient. The risk of inducing methemoglobinemia by administering the nitrite portion of the cyanide antidote regimen to a stable patient may outweigh the benefit. The stable patient exposed to cyanide should receive high-flow oxygen, as this therapy is beneficial, nearly ubiquitous, and carries no risk. Alternatively, providers could use only thiosulfate as the antidote in the stable patient, which has a greater margin of safety than does the administration of nitrate. Experts also have commented that the algorithms do not address delayed pulmonary toxicity from agents such as phosgene. This would not change the early management and decontamination of casualties, but it is an important issue and will be addressed in future versions of the algorithms.

With regard to the care of the stable, contaminated patient during the decontamination process, the use of Level-C PPE is recommended. Level-C protection includes a chemically resistant, splash suit, an air-purifying respirator, a face shield, and gloves. If patients are stable and decontamination is occurring in a ventilated area, it is unlikely that the concentration of an aerosolized agent poses a significant risk to healthcare workers.[36–38] The PPE recommendation for dirty resuscitation is controversial[12,39] and difficult to describe using the current US Occupational Safety and Health Administration nomenclature. Adequate protection for hospital-based, dirty resuscitation includes a chemically resistant splash suit, butyl rubber gloves and boots, and a powered, air-purifying respirator hood. The unstable, chemically contaminated victim may be releasing (off-gassing) aerosols that would not be fully filtered by an N-95 mask without a charcoal or organic vapor cartridge. This level of protection is a compromise between Level-B and Level-C protection. Additionally, unstable victims of high-risk biological agents have led to infections despite use of a N-95-like mask during resuscitations.[4] Given the risks associated with handling unstable biological casualties, the above precautions are warranted during a suspicious resuscitation until it becomes apparent that the agent is of low transmission risk, (e.g., anthrax). This is a novel extension of the dirty resuscitation concept into the area of biological casualties.

Decontamination is recommended for all bomb victims. Although this is controversial, there is a need to balance the safety of healthcare personnel with the safety of the victims. Though evidence regarding the handling of combined victims is rare,[22] the current threat remains real and should be addressed in the algorithm. With the evolution of rapid chemical and biological detectors, scene contamination may be ruled out early during future bomb attacks. In situations in which the scene has been cleared by the appropriate authorities, decontamination of all blast casualties is not recommended.

Regarding the definitions of overt and covert, the authors recognize the definitions may vary among different audiences. As it is used in the "Attack" algorithm, covert means that although many people are arriving with similar symptoms, the agent is unknown. However, within the law enforcement and intelligence communities, covert is defined as an unknown operation or attack. Using this definition, the obvious witnessing of hundreds of people becoming ill following the Tokyo sarin attack would be considered overt and not covert. From the perspective of a heathcare worker, however, the paradigm reflects unannounced and unanticipated disease presentations and, therefore, would be considered a covert attack until the agent was known.

The algorithms were created to address the symptomatic patients that initially present to individual hospital emergency departments. Specific public health decisions, such as large-scale quarantine, mass vaccination plans, or mass distribution of prophylactic antibiotics, are beyond the scope of the algorithms. Vaccine availability and decisions on groups to vaccinate will be made on a regional public health level.

The algorithms do not address the management of vast numbers of psychological casualties, which is necessary in adapting to any community-wide or hospital-specific disaster. The algorithms assume that the patients are sick from the agent until proven otherwise. Patients with credible exposures to chemical or radiological agents may need to be decontaminated using this approach. When addressing the psychological casualties, one also must address the concept of security and crowd control in and around the emergency departments. Again, this is dependent on individual hospital system plans and beyond the scope of these algorithms.

Limitations

The algorithms are based on the aerosolized release of biological and chemical agents used by terrorists. History has demonstrated the use of other means of attack such as contamination of food with salmonella.[40] The algorithms do not address patients presenting with gastrointestinal complaints with no fever. Universal precautions and hand washing are in order for any patient with vomiting and diarrhea. These recommendations are similar to current medical practice. The algorithms do not address non-aerosolized ricin, but this toxin is unlikely to cause secondary illness in healthcare workers.

The algorithms do not address an asymptomatic, contaminated patient, such as a patient covered with white powder, decontamination of such a patient is recommended. Additionally, the algorithms offer limited guidance regarding the asymptomatic person with a credible exposure to a biological agent. If an exposure is known, reliance on protocols from public health agencies and the CDC with regards to management of asymptomatic patients, would take precedence.

The algorithms do not attempt to define a stable or unstable patient. This assessment is left to the provider's clinical judgment. It is unlikely that specific vital signs or neurologic parameters can be defined and validated in such a broad group of patients and/or agents. The provider may use vital signs or pulse oximetry as part of the stability assessment.

Future studies will evaluate the usability of the algorithms in triaging theoretical casualties and assess the effectiveness of teaching modalities used to reinforce the algorithmic approach. Additionally, future studies will include critical evaluation of the algorithms used in announced and unannounced mass-casualty field drills.

Conclusion

A civilian, symptom-based, algorithmic approach to the initial contact with victims of terrorist attacks, industrial accidents, or emerging infections was created. This systematic approach should aid in the early recognition of victims, and thereby minimize the likelihood of secondary contamination of healthcare workers and facilities.

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