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Mobilization of Resources and Emergency Response on the National Scale

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KEYWORDS

• Mass casualty incident • disaster response • Emergency management
• COVID 19 response

KEY POINTS

- Mass casualty incidents occur when the number or complexity of patients requiring care overwhelms the resources available to provide care
- The most common type of mass casualty incidents in the United States is the mass shooting; however, other mechanisms result in unique injury patterns
- An effective response to a mass casualty incident requires adequate planning, triage, and surge capacity.
- Depending on the scale of the event, a response using national resources may be required

INTRODUCTION

A mass casualty incident (MCI) is an event in which the number of patients exceeds the resources normally available from local resources. The number of patients needed to cause an MCI varies depending on local resources and capabilities. According to a recent survey of the National Emergency Medical Services Information system, just fewer than 10,000 MCI occur annually in the United States.[1] Although this number may seem large, many MCI are not high visibility acts of intentional violence or natural disasters that often come to mind. For example, at a critical access hospital, multiple victims of a motor vehicle crash arriving simultaneously can overwhelm the facility and impair its ability to provide effective care.

Numerous high-profile events have contributed to public awareness of MCI. Images of the September 11 attacks, the Boston Marathon bombing, and numerous active

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shooter events have been seared into our collective memory. Much as advances in trauma care are made in times of conflict, the management of MCI has undergone a subsequent evolution as a result of past events. Best practices are elucidated and experiences shared to improve our response to the next event.

This article reviews the preparation and types of events causing MCI, as well as the injuries to be expected and a framework for mobilizing the resources needed to respond. Should these local resources be insufficient, an overview of the national emergency response will be provided.

PREPARATION BEFORE A MASS CASUALTY INCIDENT

Preparation before the occurrence of an MCI is essential to ensure the best possible outcomes. The planned response for unforeseen disasters is called all hazard preparedness. An all hazards approach focuses on capabilities and capacities that are critical to preparedness for a full spectrum of events. To determine what events are possible to occur, a hazards vulnerability analysis is conducted. This process is specific to a given facility, given their location, circumstances, and surrounding areas. For example, if a hospital is located near a chemical plant, it would be reasonable to consider that an industrial explosion could be a possible event inducing an MCI. Geographic location is also paramount to consider when planning. A hospital on a fault line should consider the aftermath of a massive earthquake, whereas a facility in a hurricane-prone area should plan for operations after a major storm. In these types of events, the hospital itself could be damaged or destroyed by the event, so this contingency needs to be considered as well.

The type of event dictates what resources are necessary to respond. In a mass shooting or explosion, the predominant patient type will be trauma, who will often present to the closest hospital and create a demand on emergency and surgical services. These types of events create a short-term surge in resource demand. However, in a large-scale outbreak of an infectious disease as we have seen in the coronavirus disease 2019 (COVID-19) pandemic, the predominate patient type is medical, patients will present to many hospitals, and the resultant surge can last for months or even years. In the United States, the most common type of MCI event is a mass shooting.[2] Because of this factor, it is imperative that surgeons engage with hospital leadership in the planning and subsequent response to an MCI, should it occur. Owing to the scope of these events, response from law enforcement, emergency medical services, the local government, and surrounding hospitals will need to be considered.

The importance of MCI drills cannot be underestimated. In an article discussing the response to the Boston Marathon bombing, Walls and Zinner[3] outlined the extensive preparation and drills that had taken place at Brigham and Women's Hospital, other area hospitals, and the City of Boston. Influenced by the events of 9/11, a large, city-wide disaster drill simulated the detonation of a dirty bomb and the influx of 72 simulated patients, some of whom required decontamination. In the period between 2006 and 2012, Brigham and Women's Hospital conducted or participated in 73 separate exercises, events, and disaster activations.[3] Physicians and nursing staff from trauma surgery and the emergency department also participated in team training in a simulation center to hone the response of the trauma team. This deliberate practice and drilling likely contributed to a coordinated response and a relatively even distribution of critically injured patients among the area trauma centers; of the patients who arrived alive to the emergency department, none died.[4]

Standardized courses exist to introduce surgeons, physicians, and other members of the health care team to concepts key to response to an MCI. The American College of Surgeons offers the Disaster Management and Emergency Preparedness course, and the Society of Critical Care Medicine offers the Fundamentals of Disaster Management. These courses are similar in concept and seek to introduce participants to the concepts of incident command, triage, different types of MCI events, and expected injuries. Either course would seem to provide some framework and background to surgeons who may find themselves providing care to patients involved in an MCI.

The role of the public in the response to MCI cannot be understated. In response to the Sandy Hook shooting, the Hartford Consensus was formed. The goal of the Hartford Consensus was to provide the public with education and materials that are needed to prevent death from hemorrhage.[5] As a result of this work, in 2015 the national "Stop the Bleed" campaign was rolled out. Bleeding control stations are becoming more visible in public spaces and aim to provide the appropriate equipment to complement a trained provider of basic bleeding control. In response to the blast injuries observed in the aftermath of the Boston Marathon bombing, first responders were forced to apply improvised tourniquets. Six patients arrived at the Massachusetts General Hospital with improvised tourniquets in place, but they were all noted to be venous and therefore ineffective at stopping ongoing hemorrhage. These patients were converted to a Combat Application Tourniquet upon arrival to halt ongoing bleeding.[6] Although none of these patients ending up dying, in a situation where transport times were longer or if care were delayed, this outcome could be anticipated to not be as favorable.

TYPES OF EVENTS CAUSING MASS CASUALTY INCIDENTS

One of the key components to responding to a MCI is classifying the type of MCI present. Local and federal agencies tailor surge plans in preparing for anticipated, progressive, insidious and sudden-onset disasters occurring within the community. Common types of events causing MCI are summarized in this section.

One of the main types of MCI worldwide has been caused by active shooters with the intent of mass killings. Mass shootings have been defined as 3 or more killings in a single event. In the United States, where there has been an intensifying epidemic of violence, the most common MCI is a mass shooter event.[2] The Las Vegas Massacre is the deadliest mass shooting in the history of the United States, with 58 killed and 422 injured. As shown in the aftermath of this particular MCI, mass shootings are subject to a wide array of severity of victims owing to the type of weapon used, the accessibility that the shooter has to the population they are targeting, and the ability of law enforcement to reach the shooter.

Modern warfare has shifted toward civilian arenas and millions worldwide are now at high risk of experiencing an intentional act of harm event.[7] Terrorist attacks are usually described as the intent to harm a large group of the population to achieve a political gain. Different types of terrorist attacks include active shooters, improvised explosive devices, and vehicle attacks. Many of these events lack sophistication and yet have been able to cause large-scale loss of life.

Weapons of mass destruction can certainly cause an MCI on a large scale. These weapons include chemical weapons, biologic agents, and nuclear or radiologic devices. Infectious agents such as anthrax can be leaked purposely to expose people in the masses. Weapons of mass destruction are unique because, once in the environment, they can exist as a combination of solid, liquid, or gas. The method of distribution is an important to consider and ultimately dictates how many people can be affected. Gas or airborne particles such as inhaled anthrax spores result in an immediate response. Skin exposure to liquids or solids may take time to be absorbed directly through the skin or can be transferred to mouth and be ingested. Response to these types of events are often multidisciplinary and require specialized training and equipment.

Natural disasters such as landslides, tornadoes, earthquakes, and tsunamis are a type of MCI where more than 100,000 people are killed around the world and millions more are injured or disabled each year.[8,9] Unfortunately, in most natural disasters, people have either minimal or no time to prepare or seek shelter during these, contributing to the severity of the MCI. Other contributing factors that must be accounted for is the widespread destruction that can affect hospitals and emergency response teams that impairs their ability to respond. This situation was seen in the wake of the catastrophic tsunami in the Indian Ocean in 2004. This disaster highlighted the difficulty in providing medical care without an intact building to do so.

The typical perception of an MCI is associated with a catastrophic event such as a natural disaster, shooting or bombing as described as elsewhere in this article. The COVID-19 pandemic is quite the opposite; it is caused by an unseen virus, yet the effects on the health care infrastructure have been severe. The COVID-19 pandemic has been described as an MCI of the highest nature, straining health care systems across the world owing to continued waves, causing a continued state of surge capacity. It is evident that the management of the COVID-19 pandemic has demonstrated the worldwide challenges of facing a global viral outbreak and, as such, must be described as an unconventional MCI.

Smaller scale MCIs that can affect smaller communities include multiple vehicle or bus collisions and building or bridge collapses. Any of these where 3 or more victims are involved can quickly overwhelm smaller facilities with less surge capacity. Other important MCIs to consider are airplane crashes. Most crashes involve small airplanes and few trauma centers ultimately have experience with triaging victims inured in major commercial airline disasters owing to the historical high mortality rate associated with aviation disasters.

TYPES OF INJURIES

Injuries sustained in an MCI will vary based on the type of event. Because mass shootings are the most common cause of MCI, gunshot wounds can be expected to predominate. Compared with the majority of gunshot wounds often seen in trauma centers across the country, which tend to be inflicted by handguns, patients injured in a mass shooting event have a higher likelihood of being wounded by a firearm discharging a high-velocity projectile. These higher velocity rounds such as those fired by AR-15 and AK-47 type rifles, possess a greater amount of kinetic energy. This greater amount of kinetic energy will create a greater cavitation effect[10] and upon impact with tissue can lead to devastating wounding effects.

An MCI caused by an explosion can result in blast injury to survivors. Blast injury is a caused by 4 separate mechanisms categorized as primary, secondary, tertiary, and quaternary. A primary blast injury results from the dissipation of energy from the blast into tissue. This overpressure can injure hollow structures such as the lungs, hollow viscus, and the tympanic membrane. Secondary blast injury results from the fragmentation effects related to the explosion, which can cause penetrating injuries. Tertiary blast injury occurs when the blast wind propels victims against solid objects, such as a building or the ground. Blunt and penetrating injury can result. Finally, quaternary blast injury are miscellaneous injuries such as a flash burn or crush injury sustained when a building collapses on a patient.

Another injury pattern that can result in an MCI is the dismounted complex blast injury. A dismounted complex blast injury is characterized by high-energy injuries to the extremities, pelvic and perineal soft tissue destruction, penetrating truncal wounds, and fractures to the pelvis and spine. This injury pattern is associated with massive hemorrhage. It is the signature injury pattern resulting from the conflicts in Afghanistan and Iraq. Injuries seen as a result of the improvised explosive devices used in the Boston Marathon attack were similar to those seen in deployed combat settings.[6]

Patients who are pinned or trapped beneath heavy objects such as a building collapse during an earthquake or an explosion can suffer a phenomenon known as crush syndrome. Crush syndrome is characterized by hypovolemic shock, hyperkalemia, and arrhythmias. If not recognized, crush syndrome can result in disseminated intravascular coagulation, acute respiratory distress syndrome, sepsis, multiple organ failure, and death. Three criteria should raise suspicion for crush syndrome, including the involvement of a large muscle mass, prolonged compression (typically 4–6 hours), and signs of vascular occlusion. Before extrication, empiric hydration with saline is essential to prevent the decompensation associated with reperfusion. Mannitol may act as a free radical scavenger and promote diuresis. The use of sodium bicarbonate is somewhat more controversial, but can be considered. Patients suffering from crush syndrome may need hemodialysis. Because an event creating a large number of patients with crush syndrome may exceed the supply of dialysis machines available, peritoneal dialysis can be considered, assuming there are no concomitant abdominal injuries.

The possibility that patients may be contaminated with a hazardous substance or nuclear, biological, or chemical agent should be considered. Coordination with the local fire department hazardous material response team will be beneficial but, depending on the scale of the incident, response to the hospital may be limited to assist. This scenario has many implications, especially for responder safety and to maintain the capability of the facility to continue to function treating patients. The protection of health care workers and the facility is critical. A detailed discussion of the effects of various agents, personal protective equipment, decontamination, and treatment is beyond the scope of this article.

INCIDENT COMMAND

During routine operations, most organizations that would be active in response to an MCI function independent of each other. In a hospital, for example, support from outside organizations is not essential for daily operations. However, if an MCI or other disaster were to occur, a coordinated response from all agencies is essential. The incident command system (ICS) provides the framework for this response. In the ICS, command and control of personnel and equipment are a key tenant, as is the coordination of efforts in response to an event. The ICS exists at the local, state, and national levels, as well as a hospital-based system. At the local level, the ICS is at the core of a coordinated response.

The hospital incident command system (HICS) is the most used arrangement for hospital disaster response. It consists of a command group and 4 sections, which includes operations, planning, logistics, and finance/administration (**Fig. 1**).

The command group of the HICS is responsible for the overall operation and consists of the incident commander, public information officer, safety officer, liaison officer, and medical and technical specialists. The public information office role should not be understated. After conducting a survey of those involved in managing an

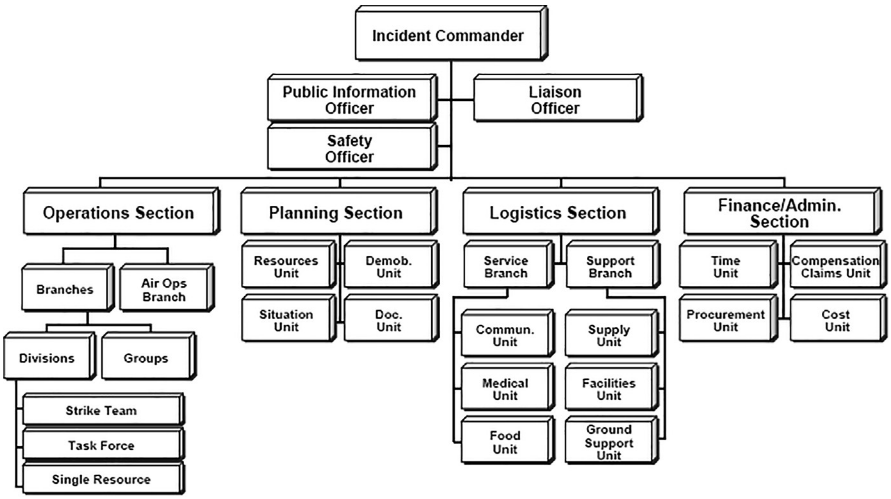

Fig. 1. ICS structure.

MCI at a recent meeting of the American Association for the Surgery of Trauma, one of the most unexpected aspects of the response was demand for information, requests for interviews, and even the arrival of politicians and celebrities while patient care activities were still surging.[11] These issues could be mitigated by scheduled press briefings, providing updates via a website or social media, and setting up a hotline for information requests.

The operations section in the HICS model manages the objectives as given by the incident commander. Within the operations section, there are 5 branches, including staging management, medical care operations, infrastructure operations, security, business continuity operations, and hazardous materials.

The planning section develops an incident action plan by collecting, evaluating, and disseminating various status reports and information. Four units exist within the planning section, which includes resources, situation, documentation, and demobilization.

Necessary resources from both internal and external sources are coordinated by the logistics section. Service and support are the 2 branches under the logistics section.

Finally, finance and administration make up the last section of the HICS. This section develops financial and administrative procedures to support the program before, during, and after the event.

Triage

Those who are dangerously wounded should receive the first attention, without regard to rank or distinction. They who are injured in a less degree may wait until their brethren in arms, who are badly mutilated, have been operated on and dressed, otherwise the latter would not survive many hours; rarely, until the succeeding day.

—Baron Dominique Jean Larrey (surgeon-in-chief to Napoleon's Imperial Guard)

The concept of triage is used on a regular basis in surgical practice. Almost daily, surgeons perform triage, whether it is to decide which patient is the sickest and needs to be evaluated first or deciding that an emergent case should supersede a scheduled elective case. Disaster triage is used in an MCI. Its primary goal is to do the greatest amount of good for the greatest number of patients. The goal is not to limit or ration care. In other words, by prioritizing patients, the use of scarce resources can be optimized.

Triage can occur at several points during a given patient's course through the system. Primary triage occurs in the field and is usually performed by emergency medical services personnel using simple criteria. Immediately upon arrival to the hospital, secondary triage occurs by an emergency physician or surgeon, typically. At this stage, the goal is to provide critical initial interventions focused on the airway, breathing, and circulation. Tertiary triage occurs after these interventions and assigns patients to surgery, the intensive care unit (ICU), or radiology. A surgeon, experienced in the care of the injured, will typically perform this role.

Different protocols for triage exist and are applied at different junctions along a patient's path through the system. Historically, most triage protocols in use were intended for primary triage. The Simple Triage and Rapid Treatment system places patients into color-coded group that correspond with a tag that is placed with the patient based on their condition. Three main groups of patients are identified with the Simple Triage and Rapid Treatment triage system. Patients likely to survive whether they receive care or not are classified as green/minimal or yellow/delayed. Those who will benefit from immediate interventions are assigned red/immediate. Finally, those who are likely to die despite maximal therapy are given a black tag. Parameters evaluated to perform Simple Triage and Rapid Treatment triage are respiratory rate, perfusion, and mental status. If a patient has a respiratory rate of more than 30 breaths per minute, capillary refill of more than 2 seconds, or is unable to follow commands, they are assigned to the red/immediate group. The remainder of patients are classified as yellow/delayed. If a patient can walk and move to a designated area, they are assigned a green/minimal tag. Otherwise, a deceased patient is determined by apnea after basic maneuvers to open the airway (Fig. 2).

Tertiary triage is somewhat more complex and can also involve patients not injured or affected by an MCI. The goal is to identify patients likely to benefit from treatment as well as those who are too sick to recover despite care. A common protocol in use for tertiary triage is the Ontario protocol, which has contains elements of inclusion criteria, exclusion criteria and minimum qualifications for survival. This protocol uses the Sequential Organ Failure Assessment score.

Triage is an ongoing process and is not static. If a patient's condition changes, their assignment may change. To be effective, there must be a balance between overtriage and undertriage. These terms pertain to the accuracy with which patients are triaged. Undertriage is when the severity of a patient's condition is not recognized, which results in a delay in treatment that can result in death. Overtriage can also increase mortality by depleting resources, fatiguing staff, and impairing patient flow to definitive care.

SURGE CAPACITY

Surge capacity is defined as the ability to respond to an increased number of patients. Capability as it relates to a surge is the ability to address unusual or specialized medical needs of an increased number of patients.

The ability to respond effectively to an MCI requires the ability to provide definitive care. Roccaforte and Cushman[12] wrote that a critical component of disaster planning must be the preservation of definitive care area capability and effectiveness. Definitive care areas were defined as the operating rooms and the ICU.

Expansion of operating room and ICU capacity depends on physical space, staffing levels, and the availability of supplies and equipment. Upon notification of an MCI, any

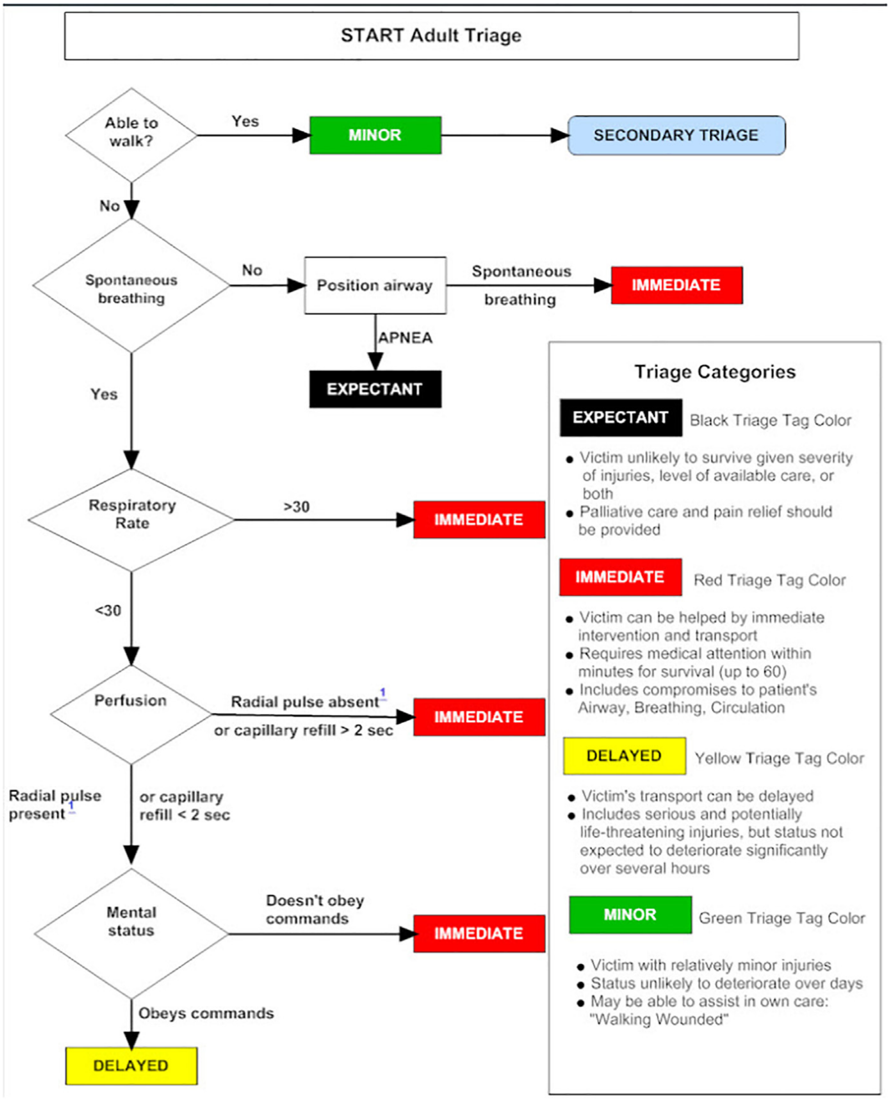

Fig. 2. Triage flow chart.

patients who can be moved from the ICU should be transferred. Elective cases should be canceled. Mobilization of additional staff should commence per the institutional disaster or MCI plan.

During the COVID-19 pandemic, institutions have had to get creative to create surge capacity. Pandemic surge staffing models were put out by Society of Critical Care Medicine, which used non-critical care trained physicians, advanced practice providers, and certified registered nurse anesthetists to care for larger number of critically ill patients than could be managed by a single intensivist. Similar models were used for nursing staff. In teaching hospitals, house staff were taken off elective rotations to form COVID-19 ICU teams. Other institutions created surgeon-led teams to place vascular access and perform other procedures needed in the ICU to offload the medical ICU team.

Depending on the nature of the event, additional critical care spaces can be created from unused operating rooms or the postanesthesia care unit.

Our institution internally developed a protocol using ultraviolet light to decontaminate one-time use personal protective equipment so it could be used multiple times safely. By doing this, the hospital's supply of N95 respirators was able to be extended until some of the stress on the supply chain could be relieved (Fig. 3).

SURGICAL CARE DURING A MASS CASUALTY INCIDENT

The surgical care that needs to be provided will depend on the type of event. A recent review of contemporary mass shootings conducted by the Eastern Association for the Surgery of Trauma found that the most common injury among survivors were to the appendicular skeleton. As a result, many patients required interventions that were orthopedic and vascular in nature. Survivors were less likely to have injuries to the head or torso, yet laparotomy was the most commonly performed procedure.[13] Another review evaluating the injury characteristics of the Pulse Nightclub shooting in Orlando found that there were no acute neurosurgical interventions performed in the first 24 hours. The most needed surgical specialists were trauma and orthopedics.[14] This finding is of interest, because many facilities will have back up mechanisms in place for trauma surgery, but may not for orthopedic surgery.

Damage control resuscitation and damage control surgery should be applied liberally in an MCI. Most surgeons who provide trauma care will be familiar with these concepts, but in the context of an MCI, damage control resuscitation is advantageous because it typically results in fewer blood products being transfused, which could limit the strain on the blood bank. Damage control surgery has benefits in the MCI setting because operative times are typically shorter, allowing the limited resource of the operating room to be used to benefit another patient. In additional, because MCI tend to be chaotic, the patient will likely benefit from a second look procedure to help reduce missed injuries or potential complications.

EMERGENCY RESPONSE ON A NATIONAL SCALE

As outlined elsewhere in this article, the initial response to a catastrophic event is primarily local in nature. However, such an event may occur that overwhelms the local response. In this case, additional resources can be made available from the federal government. Multiple federal agencies, including the military, have vast resources at their disposal. These resources will not likely be available immediately owing to the time they would likely take to mobilize.

There are numerous federal agencies involved in a response to a large-scale MCI. Unless the situation is classified as a national security event, a coordinated federal

Common themes identified in responses to military and civilian mass casualty events as described by the panelists

- Assume nontraditional duties
- Make space by any means necessary
- Revisit, review, retriage
- Plan to deal with the media
- Take care of hospital staff

Fig. 3. Common themes identified in response. (*Adapted from* Russo RM, Galante JM, Holcomb. Mass casualty events: what to do as the dust settles? Trauma Surgery & Acute Care Open 2018;3:e000210.)

response does not occur. A state's governor could request a presidential declaration of a disaster, which would allow for response from the federal government. Federal agencies likely to be involved in a national response would be the Department of Homeland Security, the Department of Health and Human Services (DHHS), and the Department of Defense (DoD).

The primary operational arm of the Department of Homeland Security is the Federal Emergency Management Agency. The Federal Emergency Management Agency conducts 15 emergency support functions, several of which would be beneficial in a large-scale MCI, including public health and medical services, urban search and rescue, and emergency management.

The DHHS is another important agency involved in federal disaster and MCI response. Within the DHHS, the Assistant Secretary for Preparedness and Response coordinates disaster response activities. A key asset that is a public–private partnership is the National Disaster Medical System (NDMS). The NDMS is a partnership between the Department of Homeland Security, the Federal Emergency Management Agency, the DHHS, the DoD, the Department of Veteran Affairs, and civilian hospitals and health care professionals. The NDMS serves 2 purposes. It is a backup to military health care operations in case of a war resulting in overwhelming numbers of combat casualties. Second, the NDMS coordinates provision of national health care resources to casualties resulting from disasters in the United States and its territories.

The main operational unit of the NDMS is the Disaster Medical Assistance Team (DMAT). There are approximately 85 DMAT teams throughout the nation. DMAT teams have physicians, nurses, and other allied health care professionals on their rosters and each have approximately 100 members. Teams can deploy on short notice and are designed to be self-sufficient for 72 hours. A DMAT team can operate autonomously, or they can be used to supplement another facility's response. During the COVID-19 pandemic, DMAT teams have been used to augment hospital staffing during times of surging numbers of patients.[15] The NDMS also contains specialty teams such as trauma and critical care teams, disaster mortuary operations teams, and veterinary response teams.

Another important component of national preparedness is the Strategic National Stockpile (SNS). The goal of the SNS is to be rapidly mobilized to provide pharmaceuticals and medical supplies to areas affected by public health emergencies or disasters. Owing to concerns for increased demand, dependence on global supply chains and the just in time inventory practices used by hospitals it is vital to maintain certain amount of essential supplies and equipment.

Contained in the SNS are personal protective equipment, medications, vaccines, mechanical ventilators, and CHEMPACKS. CHEMPACKS are antidotes to nerve agents that are stored throughout the country in such a way that 90% of the population of the United States lives within 1 hour of a CHEMPACK stockpile. Mechanical ventilators deserve special mention as well, especially in the setting of the COVID-19 pandemic. Many ventilators contained within the SNS were not full featured models useful for patients with acute respiratory distress syndrome. Consequently, many hospitals were left to procure additional ventilators that were more suitable for patients with COVID-19 with acute respiratory distress syndrome.

The DoD possesses vast resources and capabilities that can be used to supplement a local response when those resources are overwhelmed. A military response to an MCI is governed by several statutes and laws collectively known as Military Support to Civilian Authorities. The support available from the DoD and military are classified as mass resources or unique resources. Mass resources can be additive to the response provided by other agencies, whereas unique resources can provide

Mass Resources	Unique Resources
Military hospitals (75) and personnel	Deployable public health laboratories
Deployable medical platforms • Air force expeditionary medical support • Navy hospital ships	Specially trained response teams • Army chemical and biological special medical augmentation response team • Navy special psychiatric intervention team • Air force radiation assessment team
Air assets	

Fig. 4. Military resources.

technical assistance and expertise. Although these resources can certainly be impactful, their optimal use requires thoughtful planning and integration into the civilian response. For instance, during the COVID-19 pandemic, the US Navy deployed its 2 hospital ships, the *USNS Comfort* and the *USNS Mercy*, to New York and Los Angeles, respectively. Despite their 1000-bed capacity, the ships were not intended to treat patients suffering from a pandemic illness. Subsequently, both ships treated a small number of patients relative to their vast capabilities during their deployments (**Fig. 4**).[16]

SUMMARY

An optimal response to large numbers of critically ill or injured patients requires the rapid mobilization of resources. The principles of the ICS, triage, and surge capacity provide a framework to mobilize and apply resources to benefit the most patients. This approach is essential to limit morbidity and mortality in these situations. Large-scale events may require a coordinated response from the federal government if local resources are overwhelmed. Depending on the type of events, the surgeon can expect to play a key role in the response.

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