19 Emergency Department Response to Explosive Incidents: Scope of the Problem and Operational Considerations

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Introduction

This chapter provides a broad introduction to critical emergency department operations in response to an explosion-related mass casualty incident (MCI). Although malicious action as a cause is a common concern, not all explosive incidents are terrorism or intentional bombings. Storage facilities for petroleum products, fertilizer, and other chemicals and fireworks factories have exploded, resulting in tremendous loss of life in recent years [1–5]. The two deadliest events in recent US history were the 2013 West Fertilizer Company ammonium nitrate arson explosion that killed 15 and injured 160 [6] and the 2010 West Virginia coal mine dust explosion that killed 38 men [7]. Regardless of the intent surrounding the incident, all explosion-related MCIs have added layers of complexity tied to security, decontamination, information management, and complex polytrauma. Preparation is needed in all hospitals, not just those located in areas vulnerable to terrorism.

Scope of (Part of) the Problem

The Explosives Incident Report is an informational product prepared by the US Bomb Data Center, using incident data reported in the Bomb Arson Tracking System (BATS), that examines the total number of annual explosive-related incidents. It includes explosions and bombings, recoveries, suspicious packages, bomb threats, hoaxes, and explosives thefts or losses. In 2017, the most recent report, BATS captured a total of 687 explosions of which 335 were bombings. Both total explosive incidents and bombings decreased significantly since 2014. Total explosive

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incidents are down by 25%, and bombing incidents as a subset decreased by 48% over those 3 years [8]. Epidemiological statistics for accidental explosions are not included in this report.

The Disaster Surge Plan

The emergency department (ED) and hospital must have a plan to effectively manage explosive incidents. The US Department of Health and Human Services and the Centers for Medicare and Medicaid Services provide some general recommendations for effective healthcare facility disaster planning [9]. A hospital must develop a workable and relevant emergency operations plan (EOP). The structure recommended is an all-hazards approach that allows the ED to manage all disasters both internally and externally. Please refer to Chap. 24 in this textbook for detailed information on these topics.

The planning process should include a mechanism by which the EOP can be continually adapted in response to changing requirements and emerging threats. Changes in ED infrastructure, staffing models, trauma protocols, and supply availability may also force changes. Each hospital should develop and facilitate an emergency management committee composed of administrative, physician, nursing, and ancillary support department leaders. This committee should meet regularly to review significant hazards and modify the EOP as needed. Emergency plans should be exercised frequently to improve skill retention [10].

Command and Control

The ED frontline providers are generally responsible for recognizing a disaster/surge situation, communicating with hospital leadership, and coordinating other specialty engagement. Once the EOP is activated, major decision-making responsibility transfers from the ED attending to representatives of the hospital administration and emergency management committee. The Hospital Incident Command System (HICS) is a scalable administrative model designed to streamline this process [11]. The HICS is discussed in significant detail in Chap. 24 of this text.

Large explosive MCIs will likely require command and control functions to also incorporate local, federal, and private partners. Local health departments and healthcare coalitions can be integrated into all functions of the hospital management system to assist in resource acquisition, trauma and burn region-wide system activation, incident intelligence, and family reunification. For catastrophic events, the federal government can provide resources through mechanisms administrated by the Federal Emergency Management Agency and the Department of Health and Human Services.

Emergency Department Logistics

The resources available to an ED to provide care are critical to the management of mass casualties of any cause. Resources can be divided into four categories: staffing, services, space, and supplies. The planning phase for any MCI should include developing a system of activation, accountability, maintenance, and recovery within each category. This is vital to be able to sustain short-term and long-term operations, including care for patients who were not victims of the incident.

Each department should have a plan to expand their services. Support services such as laboratory, materiel management, and plant services must be ready to augment their capabilities to meet increased demand, operating room use, and equipment needs during a surge in patient volume. The medical services depend on the ability of the supporting services to parallel their expanding and changing needs.

Modification of existing hospital spaces during a surge event can expand the patient care footprint quickly. Large areas such as the cafeteria, atrium, and auditorium can be used alternatively as family reunification centers, personnel "triage" and staging sites, and care areas for minimally injured patients. Outpatient clinics, classrooms, and meeting spaces can be used as minor patient treatment areas, storage, or other uses. Each facility is unique, and the disaster plan should clearly delineate these sites for alternative use. The ED space, in particular, will need to be adapted to fit the needs of arriving patients and to maximize staff efficiency. Capacity can be created by converting non-critical care rooms into critical care capable spaces by adding needed monitoring equipment, procedure kits, ventilators, etc. Additional patient care spaces can be created by utilizing appropriate hallway beds and by converting single patient locations into multiple patient spaces. This can be done quickly but will also require additional critical care equipment, procedure materials, and other trauma/burn supplies. Doubling the critical patient load in an ED may tax the infrastructure. The logistical support for these types of changes must consider appropriate access to generator power, information technology services, food and water, and toilets for patients and staff.

Hospitals typically store 48–72 hours' worth of supplies to maintain normal operations. In a blast incident, those supplies may be quickly exhausted. The surge plan should detail means of obtaining additional supplies from distributors, the health department, and associated healthcare coalition partners. Supplies include, but are not limited to, medications, blood products, surgical materials, specialty items such as radiology contrast, lab-testing materials, and reagents. Sterile processing facility's staff and supplies should be immediately augmented for surgical equipment turnover. Members of the material management and sterile processing teams should be included in the operational branch of the HICS to ensure needs are being met.

Communications

Communication in a disaster is paramount to the success of most operations in the prehospital and hospital setting. The entire system of care requires effective communication, including but not limited to on-scene dispatch, hospital trauma notifications, staff recall, and real-time resource management. A PACE-based communication plan should be considered for each phase of operations to ensure redundancy of communication. PACE is a communication planning modality that stands for Primary, Alternative, Contingency, and Emergency:

- *Primary* – The primary or usual means of communicating during day-to-day operations.
- *Alternative* – The first "backup" system of communicating should the primary system fail.
- *Contingency* – Third-line communication system, the "backup to the backup."
- *Emergency* – The plan for when all prepared means of communication fail.

An example of the communication PACE plan in practice was during the May 22, 2011, EF-5 tornado that severely damaged St. John's Regional Medical Center in Joplin, Missouri. The damage destroyed portions of the hospital including its primary communication system. One hundred and eighty-three patients required vertical evacuation to safety without their primary system of communications, landline telephones. Cellular phone voice calling was expected to suffice as the alternative mode, but cellular voice calling was also unavailable. However, personal cellular phone text messaging and social media sites were available and were utilized as a contingency plan for communications, leading to a successful evacuation [12].

Communication with Prehospital EMS Providers

Except in rare circumstances, receiving hospitals will be notified to expect patients from the scene of an explosive incident prior to arrival. High-casualty events will require the local EMS dispatch center to coordinate with multiple hospitals quickly in an effort to distribute patients appropriately to prevent overwhelming any individual ED. The infrastructure for such communications and coordination differs by jurisdiction and city size. In small locales, there may be only a single EMS provider, hospital, and associated dispatch. In large cities, there are special communication centers in place to manage these tasks. During mass casualty situations, these centers play a key role in determining the appropriate location and timing for transport of triaged survivors to medical facilities. In the immediate aftermath of the Boston Marathon Bombing, the local Central Medical Emergency Direction Center (CMED) determined the number of patients each ED could accept and coordinated distribution of patients to each center. CMED centers play a role in assisting field medics with communications during an event by connecting them directly with medical control and receiving hospitals, managing radio channel usage,

maintaining clear EMS communications procedures within a region, and providing interoperability with other public safety agencies [13]. Particularly during a multi-jurisdictional response, heavy or unreliable radio traffic may lead to confusion and operational mistakes. Most EMS systems employ redundant means of communications and multiple available frequencies of radio communication.

Communications Within the Hospital

Within the hospital environment, redundant means of communication are recommended even during normal working conditions. Barring power loss, telephones, pagers, and overhead announcements will serve as the primary means of communication between physicians, administrators, nurses, and departments during an MCI as well. In the event of power or phone losses, human "runners" can serve in lieu of telephones or pagers. Whatever the system, pre-incident planning and training are prerequisite to success.

Staffing Needs

A good disaster plan is not binary. It must be scalable and able to be tailored quantifiably to the number of injured patients expected. Hospitals should activate staff early in order to meet the projected demand. There must be a system of checking in, deployment, and accountability for staff members and volunteers. A majority of US hospitals operate at overcapacity on a daily basis. Limited staff availability could make it very hard to meet manpower needs during a mass casualty surge [14]. A system of rapid notification and recall of hospital staff is a mandatory plan component. Such systems include calling staff from a phone list, autodialing "robocalls," mass text messaging systems, and even television announcements.

Recall must include not only ED physicians and nurses but also trauma surgery, ICU, and anesthesia. Not to be forgotten is the need for inpatient medicine providers. While their utility may be quite limited in the care of arriving trauma victims, medicine staff should take immediate care of all boarding, recently admitted, and admission-pending patients. Nurses from critical care areas should be considered as options to support the ED. Instructions to recalled staff should provide clear, specific directions detailing exactly where to report so that they may be "triaged" to areas of need. Instructions should include known information on street closures, security measures, and potential threats. The logistics leadership should plan to provide food, water, and sleeping arrangements during the operational period. Technicians, medical students, EMS providers, and other qualified personnel can be utilized to transport patients within the hospital, as there may be a large increase in transport use, and also to monitor those patients being cared for in auxiliary locations.

Environmental services (EVS) staff deserve special mention. Without augmented housekeeping staff, ED and OR staff will be responsible for room cleaning and "turnover" which will cause significant delay and distraction from patient care. The

EVS leadership should be involved in disaster planning at least annually. Security staff will need to be augmented. In addition, they may have particular needs that they must address through contact with local law enforcement (such as extra armed staff).

Emergency Department Operations

Surge capacity in the healthcare sector can be defined as the maximum augmentation of resources available to care for the influx of an unexpectedly large number of patients [15]. Surge capacity is a critical function of a hospital's ability to manage mass casualties from a sudden event such as an explosion. Factors that determine surge capacity include availability of extra staff, supplies, and the number of empty licensed beds. The most critical means by which surge capacity can be increased is by discharging inpatients to home or other facilities when safe to do so. Reverse triage, a concept of discharging patients from the hospital early if they are considered low risk for any significant medical consequence that continued admission can prevent or treat, has been studied. If appropriately harnessed, it can be a major contributor to increasing surge capacity [16]. Depending on the size of the event, increasing patient capacity will require not only ED decompression but also the inpatient wards.

However, even if inpatients are identified who are appropriate candidates for immediate hospital discharge or transfer to unaffected inpatient facilities, completing these tasks is time-consuming, and inter-hospital transport ambulances may be limited. The nursing staff who routinely perform these tasks may be already involved in the disaster response elsewhere in the hospital and therefore may be unavailable. Temporizing options can be instituted in such a case. As patient rooms and physical space on medical wards become the priority need, patients awaiting discharge to home can be taken to a designated area elsewhere in the hospital. Such a "discharge waiting room" requires minimal staff and patient care supplies (wheelchairs, home oxygen, access to scheduled medications) while these stable patients await completion of their discharge paperwork. Additional inpatient capacity can be achieved by temporarily converting single patient rooms into multiple patient rooms. Noncritical patients in private rooms can be "doubled up" if space, electrical power access, and patient safety allow.

Decompressing the emergency department of patients is a critical immediate step when facing a large patient surge following an explosion. In an ideal situation, every patient would be accurately triaged in the ED, would receive relevant laboratory and radiological evaluation, and would be assessed by all necessary consultants. During a surge event, this may be impossible, and typical ED care may need to be abbreviated when it is safe to do so. In accordance with the Emergency Medical Treatment and Labor Act (EMTALA), all patients must undergo a medical

screening evaluation (MSE) in the ED. Patients without an emergency medical condition identified during the MSE should be immediately discharged to home. Others will require admission to the hospital. For those patients, inpatient medicine teams must be prepared to accept patients into inpatient areas without delay, even if a full workup is incomplete by typical ED standards. Admitting internists, intensivists, and consultants should be prepared to complete patient workups and minor procedures on inpatient wards in a manner they are not accustomed to but are qualified to perform. Inpatient hallways should be used as overflow patient care areas to increase surge capacity. For this to work effectively, incorporation into drills and disaster planning is necessary. Because safety is the priority, the fire marshal should be involved in surge planning to help identify nontraditional patient care areas that can be safe and in accordance with local laws.

Patient Inflow

Patients will begin to arrive at nearby EDs via EMS and private vehicles. Depending on the location of the hospital and proximity of the incident, some may arrive by public transportation, ride-sharing services, taxi, or foot. Research has demonstrated a bimodal distribution of arrival, with less severely injured patients arriving to the ED by non-ambulance transportation prior to the more severely injured patients who required EMS transport [17]. ED mass casualty plans must include a plan to triage all arriving casualties, regardless of their prehospital triage designation. Those arriving by EMS are likely to have been sorted in the field by a standard triage method (i.e., SALT, START, JumpSTART). Reassessment is critical. Initial field triage may be inaccurate, or the patient's clinical condition may change after this initial assessment. A multiple-layer system of assessment and triage, although not validated, are likely to improve accuracy and reduce both over-triage and under-triage.

Following an explosive event, traffic may impair ingress and egress of transport vehicles and could affect patient outcomes. This is true at the scene of the event where patients are being loaded for transport to a hospital but equally importantly upon arrival to the receiving center. In areas where traffic is a preexisting concern, hospitals should include in their mass casualty plan strategies for traffic control around the hospital to allow continuous flow of transporting vehicles. Hospital security should have a plan to control movement of vehicles into and out of the ambulance bay to prevent a bottleneck. Additional unloading points at the hospital may be necessary and should be planned for in advance.

Security concerns include safety of the hospital itself. EDs have been targets of secondary attacks, and multiple recent violent attacks have led to lockdown of EDs for fear of such violence [18]. A manned defensive security perimeter that can be quickly implemented should be part of the disaster plan.

Patient Throughput

Triage

Efficient flow of patients through the ED is critical to accommodate a surge in complex victims of an explosive incident. Initial triage at the incident site may occur and be helpful in the setting of limited transport and large numbers of injured. However, recent mass casualty events in the United States demonstrate that on-scene triage systems are limited in their utility. Injured but ambulatory survivors are utilizing alternative modes of transport that bypass EMS to seek ED care (e.g., civilian vehicles, phone app-based ride-share vehicles) and may arrive before more critically injured patients [19, 20]. This bimodal arrival of patients will disrupt the ideal on-scene triage goal in which the sickest patients arrive to the ED first. Additionally, high rates of over-triage and under-triage using standard prehospital triage systems further reduce this desired orderly arrival. Therefore, it is imperative that mass casualty plans incorporate the designation of a triage officer, preferably an experienced physician, to perform secondary triage of patients arriving at the ED, re-sorting them to specific patient care areas and teams based upon their injury severity. Continuous reassessment of patients will detect both improvements and declines in their conditions and should be performed constantly during the surge.

Registration

The flow of patients through the ED can be delayed at multiple bottleneck points. One of these that can impede care significantly during an MCI is registration and provision of a hospital identification. During normal ED operations, traumatically injured patients are typically given temporary pseudonyms (e.g., Trauma Jack) and number in an effort to rapidly assign a hospital chart and facilitate the ordering and tracking of medications and imaging. During an MCI surge of trauma victims, this type of registration may lead to medical errors if the temporarily assigned identifications are confusing or too similar. It is likely that all EDs already have a naming convention for unidentified patients. However, those existing conventions may prove confusing or inadequate during simultaneous care of many unidentified patients. One of the receiving trauma centers during the Boston Marathon Bombing found in their after-action review that "critically ill patients were checked in with our unidentified patient naming convention; however, the names assigned with this convention were difficult to distinguish from one another on the ED electronic tracking board and in downstream clinical systems" [21]. This resulted in one near-miss event and prompted a revision of their naming system, taking into account the manner in which the names appeared on department computer screens, ID bracelets, etc. A system should be designed to reduce the possibility of such errors. This should include the creation of a preexisting disaster registration set – a large number of unique, temporary identifications that will allow for immediate patient tracking, medication administration, and accurate ordering and reporting of radiological studies.

Movement to Designated ED Care Area

Emergency department space is limited and creating patient care "zones" may be useful. Prior to recalling physicians and nurses for augmentation, staffing levels will be at their lowest. Casualties will require the most immediate level of care during that time. If possible, staff should be divided into care areas, and arriving patients assigned to those areas by the triage officer. Each individual should expect to manage multiple critical and lesser injured patients simultaneously during the stabilization phase while awaiting the arrival of additional staff.

As recalled ED providers arrive to help, "staff triage" should be performed by the lead emergency physician and the lead surgeon to assign them to appropriate zones and/or patients based upon their skill and experience. Medical students and volunteers can provide valuable help and should be used accordingly. Pathology staff are often overlooked in disaster planning, but their value is significant if fatalities are present. Deceased patients should be taken to the morgue as quickly as possible, and capacity may be quickly reached. Disaster plans should include contingencies for additional refrigerated space.

Trauma and resuscitation bays should be reserved for "red" (immediate care) patients that require intubation or immediate surgical evaluation. Grouping of "yellow" (delayed care) patients together in one zone will allow for efficient evaluation and continuous reevaluation. "Green" patients, or the so-called walking wounded and worried, should be rapidly assessed and isolated in large areas that can accommodate such a mass of low-acuity patients. Walking wounded patients post explosive incident may harbor occult life-threatening injuries, and clinicians should insure a regimented reassessment process is in place.

Clinical Care

The clinical aspects of care will vary depending upon many factors. Police and fire department reports, in addition to EMS triage on scene, will likely identify the type of explosion relatively early making it clear if the majority of survivors will present with injuries caused by primary blast injury from high-order explosives or with shrapnel, fragmentation, and burn injuries typically resulting from low-order explosive improvised devices. Primary blast lung injury can present in a delayed fashion, and the treatment is primarily medical. Trauma surgery teams will manage penetrating trauma, amputations, and soft tissue and CNS injuries operatively as needed. Extensive burns resulting from the blast and resulting fires may require stabilization and transfer if criteria for burn center admission are met.

Decontamination

Decontamination may be necessary after an explosion involving hazardous chemicals, chemical warfare agents, or biological weapons. The process typically involves

disrobing and showering the patient using soap and water. If hazardous chemicals or agents are suspected, all patients and potentially exposed persons must be decontaminated prior to entry to the ED. The most common mass decontamination shower type is the "pop-up" style shower system designed to be rapidly set up outdoors. Inefficient processes may serve as an additional bottleneck to patient input and thus delay trauma care.

Criminal Evidence

Staff should be made aware that in the event that the explosive incident was an intentional attack, the clothing and belongings of patients should be considered evidence from a crime scene. Staff should follow law enforcement evidence preservation instructions. Additionally, the perpetrators of a bombing could be patients in the ED themselves and may require special security considerations. At Beth Israel Deaconess Medical Center, both brothers who perpetrated the Boston Marathon Bombings received care in the same emergency department just days after dozens of victims from their bombs were treated there. The surviving brother required surgery and a long hospital stay. There were significant security concerns associated with his residence in the same hospital where many of his victims still resided as patients requiring large-scale security staffing by local and federal agencies.

Radiology and Labs

The essence of a medical disaster is when patient needs exceed medical resources. In a mass casualty surge, radiological imaging and laboratory capabilities can become quickly overwhelmed. Following an explosive incident with large-scale shrapnel imaging, computed tomography (CT) imaging is the modality of choice to diagnose organ and CNS damage to determine the need for immediate surgical intervention. When CT availability is limited severely, it has been postulated that CT imaging should be reserved for CNS injury detection almost exclusively, relying upon thoracic and abdominal ultrasonography performed by experienced emergency specialists to detect internal injuries that warrant thoracic procedures or exploratory laparotomy/damage control surgery. A designated ultrasound team can perform serial exams on patients to reassess for newly detectable injury that may warrant intervention more quickly [22]. Bedside lab testing can be utilized if available for both quick results and to offload some of the burden from the hospital laboratory. The blood bank should be notified immediately when a traumatic mass casualty event has occurred, and the initial steps to procure additional blood products from other facilities should be explored.

Prioritization of Disposition

An additional layer of triage in the trauma bay may improve throughput. Following an explosive incident, a senior surgeon (ideally with knowledge of blast injury patterns) should serve as the leader in the "red zone" to determine timing and order of surgeries. This "OR gatekeeper" determines the ultimate need and order of emergent operative treatment and acts as the liaison between the ED and the OR [23]. Damage control resuscitation and surgery concepts, discussed elsewhere in this book, boosted surge capacity in the receiving hospitals following the 2005 London Transit bombings [24].

A senior intensivist may prioritize and direct traffic to intensive care units in the hospital. In 2016, an expert recommendation paper was published on critical care triage emphasizing key concepts including the following regarding ICU admissions during an MCI (Table 19.1) [25, 26].

Emergency Department Output

A mass casualty surge is not just an ED problem, it is a hospital and health system problem. Output includes admission to the hospital, transport to the OR, transport to the morgue, and discharge to home. The primary factors that will determine output from the ED include availability of hospital rooms and associated nursing coverage, manpower for the transport of patients to various locations within the hospital, and abbreviated registration. Just as the ED must be decompressed rapidly in anticipation of an immediate bolus of patients from the scene of an explosion, the entire hospital should be prepared to decompress inpatients, allowing for ongoing

Table 19.1 Key considerations regarding intensive care admission during a mass casualty incident [25, 26]

Triage criteria goals	Triage method choices	ICU decision-making
Objective Ethical Transparent Applied equitably Publicly disclosed	Who will likely benefit the most from the ICU care? "First come, first served" basis	Apply explicit inclusion and exclusion criteria to determine appropriateness for intensive care unit admission
Special considerations		
Consider transferring to alternative hospitals stable patients to maximize ICU space Transfer trauma patients to trauma centers if possible Transfer pediatric trauma patients to pediatric trauma centers if possible Transfer patients who meet appropriate criteria to burn centers if possible Pediatricians should be assigned to the triage area if children are among the victims		

admission output from the ED. As the response matures and the less critical yellow and green patients begin receiving care, output will transition from the OR/ICU/telemetry settings to the less acute care settings or to home. Stable patients requiring admission or specialty services should be considered for transfer to other hospitals remote from the response zone as local capacity is reached.

Media Relations

The media play a vital role in reporting information about an incident. The information disseminated to the public must be well coordinated, timely, and accurate in order to avoid confusion, anger, or the loss of public trust. During an incident, the hospital's public information officer (PIO) must work closely with other official information sources to provide "one message, many voices." This is an essential component of the HICS, which is discussed at length in a later chapter in this book. The hospital's PIO may use social media to disseminate information to the public [11]. During mass casualty and other high-profile medical events, hospital employees and visitors may choose to post information on social media sites. Employees should review their hospital social media policy to ensure compliance with confidentiality laws prior to posting potentially inflammatory statements or misinformation.

Patient Family Assistance

The HICS should designate a family reunification unit leader who will assist families in locating their loved one through the hospital's patient tracking program or the community's patient location system. Reunification of families with the deceased must also be a priority. For example, following a mass fatality event, the District of Columbia has a plan to establish a Family Assistance Center to collect antemortem information from family and friends of the missing and deceased in order to reunite them [27].

Conclusion

Explosions can result in large numbers of injured and dead. Drills and exercises practiced at the hospital level are necessary to prepare for surge events and must include all medical specialties. Normal hospital operations will be proportionally disrupted by the magnitude of the event. Disaster plans should be enacted to modify operations, recall necessary staff, and create additional surge capacity for the survivors. Special considerations include decontamination, security, involvement of specialists in disaster planning, media relations, and family assistance. Psychological care for the responding hospital staff should be provided free of cost.

Pitfalls

- Failure to conduct regular disaster drills and to familiarize new staff with disaster plans.
- Failure to coordinate disaster plans with local EMS agencies and their dispatching agents, the Department of Health, and the participating healthcare coalition.
- Failure to prepare inpatient medicine physicians for their role in the surge plan.
- Failure to have a nimble patient registration system for MCI surge.
- Failure to recognize the psychological stress experienced by staff members.

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