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The Nuts and Bolts of Preparedness and Response for Acute Disasters

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Preface

This manual is not another "disaster book." It is meant to provide a simplified blueprint for healthcare professionals and emergency managers for planning the response to the types of events that are abrupt in nature, resulting in a number of injured or contaminated patients that overwhelm the first responders as well as the local hospitals. These are the genuine mass casualty incidents (MCIs). For being unexpected, they become a real challenge not only for the medical but also the entire community.

Most of the information in this manual is derived from the author's personal experience in planning and managing the response to MCIs in Israel and other countries. Some of this knowledge was adapted to emergency medical services and medical centers in the United States and other parts of the world.

Much of the material in this manual is based on the proficiency of many experts with whom I had the opportunity to work and learn. Therefore, unlike other publications, this manual does not include many references of published literature.

I would like to acknowledge some of my colleagues, partners, teachers, and friends, who with their wisdom and spirit helped me put together this manual (in alphabetical order):

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Special love to my wife, Iris, who has always been the anchor of my life, and to my children, Barak, Lior, and Royi, from whom I learned to respect other opinions, despite being right all the time…

Finally, special appreciation to my mother, Paula, who supported me from the day I opened my eyes and to my father, Shmariahu, who was my role model. May he rest in peace.

Miami, FL, USA Mauricio Lynn

Contents

1. General Information

Definition of Disasters and Mass Casualty Incidents

In other publications, disasters and mass casualty incidents (MCIs) are interchangeable concepts. Nevertheless, from a medical perspective, there is a need to separate the definitions since almost all MCIs are "disasters" for the community, but not all disasters are associated with MCIs.

Disaster

- A disaster is a natural or man-made hazard resulting in significant physical damage or destruction, loss of life, or drastic change to the environment.
- From a medical perspective, a disaster may cause injuries, contamination, or disease to people or may be associated with only physical damage, without affecting the health of human beings.

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Mass Casualty Incident (MCI)

A mass casualty incident (MCI) is an event where the number of patients temporarily exceeds the capability of the first responders at the scene or of the medical staff at the hospital to provide optimal care to all victims simultaneously.

A MCI is a "temporary state of insufficiency."

At the prehospital phase, the "state of insufficiency" may be due to:

- Insufficient access and evacuation routes for ambulances
- Insufficient number of ambulances and/or helicopters during the initial phase
- Insufficient number of personnel (drivers, paramedics, physicians) during the first hours
- Insufficient amount of equipment and supplies

At the hospital phase, the "state of insufficiency" may be due to:

- Insufficient number of personnel (doctors, nurses, technicians, transporters, clerks, security guards) during the initial phase
- Insufficient space in the emergency department (ED) or intensive care unit(s)
- Insufficient number of operating rooms available
- Insufficient number of available ventilators
- Insufficient amount of supplies
- Insufficient number of blood units available for immediate use

Even in countries where MCIs are common, there will always be a "temporary state of insufficiency" both at the prehospital and at the hospital.

The main objective of a well-written and detailed disaster plan combined with frequent live exercises and drills is to reduce the period of "insufficiency" to a minimum possible.

Classification of Disasters and Mass Casualties Incidents

Disasters and catastrophes may be divided into two major categories, according to the initial medical response:

Progressive Disasters or Preplanned Mass Gatherings

A progressive disaster may occur over a long period of time, such as days, weeks, months, or even years.

As an example, the individuals inside the Chernobyl nuclear reactor did not survive the initial explosion, but up to these days, there is a higher incidence of thyroid cancer among those people exposed to the radiation (Fig. 1.1).

A typical progressive event is the slow spread of a biological agent (Fig. 1.2). The total numbers of infected patients may be enormous, but characteristically, not all arrive at *one* emergency department (ED) simultaneously. Sick patients will either go to their primary care physician first or to the closest ED.

Another good example of a progressive event is the slow evolution of a hurricane. Typically, the path of a major storm may be known for days before it makes landfall. Its slow progression

FIG. 1.1. Chernobyl nuclear reactor after the accident: April 26, 1986. Courtesy of RIA Novosti

FIG. 1.2. Patient with smallpox (From Centers for Disease Control and Prevention)

allows for evacuation of populations at risk and deployment of emergency personnel and equipment prior to storm arrival.

From a medical perspective, the response for a progressive disaster should be in place *before* the event reaches its full magnitude.

Similar planning and response may be used for mass gatherings, such as major sporting events, concerts, or air shows. In these situations, risk assessment is performed, potential threats are analyzed, and possible medical consequences are considered. According to the findings, all or fractions of the planned medical response may be deployed prior to the event:

- Ambulances
- Medical personnel
- Helicopters
- On-site decontamination facilities
- Preplanned access and evacuation routes

Sudden Mass Casualty Incidents

A sudden mass casualty incident (SMCI) may be a result of a train or plane crash, earthquake, explosion, or mass shooting. The

common theme of all these events is that they occur without any warning. This fact results in a "temporary state of insufficiency," described previously.

SMCIs may be of conventional nature, more commonly traumatic, blast and burn injuries, chemical exposure to hazardous materials, or a radiological dispersal device (RDD), also known as "dirty bomb."

Unlike with progressive disasters, the medical response for SMCIs is initiated *after* the event has already reached its full magnitude. This circumstance presents as a major challenge for the first responders at the scene as well as for the hospitals that need to absorb and treat a large number of injured patients, with minimal time to prepare.

A large-scale SMCI (e.g., Madrid train bombing, earthquake [Fig. 1.3]) may overwhelm the medical resources of a city, its emergency medical services (EMS), medical centers, medical examiner, and mortuaries. It is this type of incident that may require external help, from within the state, country or international.

Fig. 1.3. Relief efforts, Haiti earthquake, January 2010

Epidemiology of Sudden Mass Casualty Incidents and Its Practical Applications

The main goal of the medical response to a sudden mass casualty incident (SMCI) is to identify and manage the critical patients in an attempt to save lives. For planning purposes, it is imperative to know the approximate number of severe or critical patients to expect after a SMCI. Therefore, it is important to learn the epidemiology of such events.

Examples of SMCIs

- Explosions
- Plane crashes
- Train derailments
- Earthquakes
- Mass shootings
- Massive chemical contamination
- Radiological dispersal device (RDD) or "dirty bomb"

Regardless of the type of SMCI, the majority of the injured or contaminated patients will be walking wounded.

In all examples above, the number of critical patients that require immediate attention rarely exceeds 20 % of the total number of injured.

Planning for a SMCI should focus on directing resources, such as personnel, equipment, and supplies, to manage those few who are critically injured/contaminated and salvageable.

The concept of "the greatest good for the greatest number" is a myth, and it is not supported by any published literature regarding the severity of injuries in an urban SMCI.

2. Prehospital Planning and Response to Sudden Mass Casualty Incidents

Phases and Characteristics of Sudden Mass Casualty Incidents

All sudden mass casualty incidents (SMCIs) have common characteristics. It is important to know them since they will have a major impact at the prehospital as well as for the hospital planning of the response.

Chaos Phase

The initial minutes after any SMCI is the **chaos phase** (Fig. 2.1). It is characterized by a lack of leadership and control. Bystanders do their best to help but their efforts are uncoordinated. The arrival of the first ambulances at the scene is not synchronized, and there is little control of ambulance destination. It is during this phase that **minor injuries are evacuated first**, by private vehicles or by ambulances. It is of critical importance that hospital personnel be aware of this phenomenon and not allow the emergency rooms to be filled with minor injuries before the critical patients arrive.

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FIG. 2.1. Chaos phase after a market explosion in Jerusalem: Evacuation of injured patients performed by bystanders

It is almost impossible to control the chaos! The presence of a "yellow tape" surrounding the scene does not mean the chaos is under control.

Emptying the scene, by rapid evacuation of the critically injured, is the only way to reduce the chaos time.

Reorganization Phase

Reorganization phase (Fig. 2.2) is the second phase of a SMCI and starts when scene command and control is completed. It is characterized by the presence of a "field commander," who could be a senior paramedic, police officer, or fire fighter. It is during the reorganization phase that access and evacuation routes for ambulances are opened, proper triage of patients is performed, and even distribution of injured to area hospitals is performed according to their medical needs.

FIG. 2.2. Reorganization phase after a SMCI: EMS, fire, and police at the scene performing orderly evacuation of injured patients

Evacuation of Nonurgent Casualties

The final phase is the evacuation of the walking wounded, which typically comprises the vast majority of patients in a SMCI.

Note: With appropriate prehospital planning in combination with frequent live drills, all three phases of a SMCI should be completed within 60–90 min.

Scene Incident Command

As mentioned previously, a SMCI is characterized by an event that occurs without previous notice. Therefore, the medical response to this type of incident should be massive and immediate.

The deployment and setup of a scene incident command (SIC) (Fig. 2.3) should be tailored in accordance to the magnitude of the event and the estimated time necessary for its conclusion. Not all incidents require a fully staffed and equipped SIC.

FIG. 2.3. A complete scene incident command vehicle ready to deploy

A typical SIC should have the following representatives:

Emergency medical services (EMS)
Fire department
Police department
Search and rescue (if applicable)
Bomb squad (if applicable)

Examples:

In an event of a mass shooting or an open-air explosion, injured patients are usually visible and easily found. In such a situation, the priority is to rapidly evacuate the critical victims to area hospitals. Delays in patient transport with the sole purpose to set up a "formal" SIC will negatively impact their outcome. In this type of event, an authoritative and well-trained paramedic, police officer, or fire fighter should be sufficient to control the access and exit of fire trucks and ambulances, to and from the scene, and facilitate the even distribution of victims among local hospitals.

On the other hand, some events are more protracted in nature, where a search and rescue component is necessary or when SWAT teams need to be deployed due to questionable scene safety.

In case of a train derailment or earthquake, where victims may be trapped inside the cars or collapsed buildings, a complete SIC should be deployed and staffed. The same planning should be considered when a secondary explosive device is suspected and bomb squads need to be activated or in an active shooter situation and activation of SWAT teams.

Adequate communications between all first responders working at the scene are imperative. In this type of event, the following items are the key duties of the SIC:

- Assure safety of the bystanders and the first responders.
- Assess the safety of the collapsed structure.
- Facilitate search and rescue.
- Provide open routes for patient transport.
- Communicate with the Regional Emergency Operations Center (REOC).
- Coordinate medically adequate distribution of patients to area hospitals.

The Role of Bystanders and Volunteers in Sudden Mass Casualty Incidents

One of the most overlooked topics in disaster medicine is the role and the handling of bystanders following of a sudden mass casualty incident (SMCI).

One would think that the more assistance after an event with multiple injured patients the better. Nevertheless, it is conceivable that the presence of untrained individuals at the scene of a bombing, where the threat of secondary devices is real, in the proximity of unstable buildings in the aftermath of an earthquake or inside contaminated areas after a toxicological spill, may add to the problem rather than help with the solution. In addition, medical management of injured patients by untrained persons may worsen their medical condition. A recent example was the Boston marathon

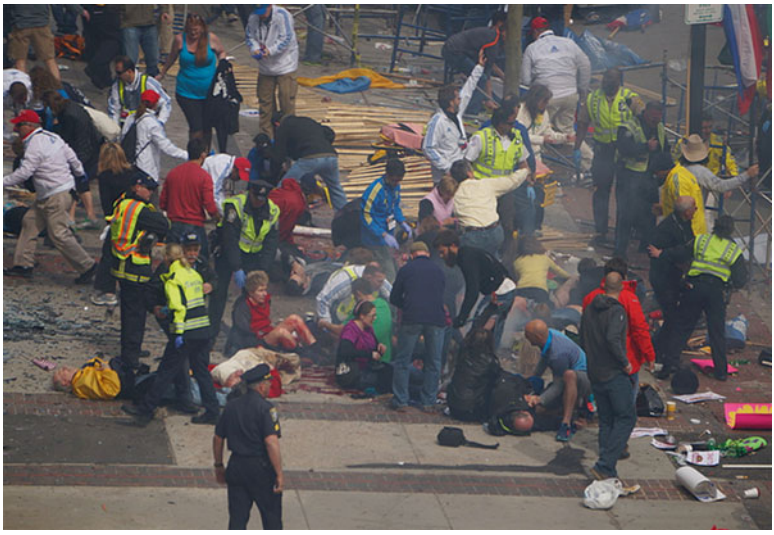

FIG. 2.4. Bystanders at the Boston marathon bombing. Courtesy of Creative Commons

bombing (Fig. 2.4). The application of improvised tourniquets by bystanders may have increased the bleeding from the extremities of injured spectators.

In reality though, it may be impossible to control the flow of bystanders during the chaos phase (page 7) of a SMCI. However, once command and control is achieved (reorganization phase), the employment of bystanders, if necessary, should follow a few important guidelines:

What to do:

- Specific skills: It is common to find individuals with specific skills (doctors, nurses, paramedics, ex-military) in attendance of sporting events, concerts, or on board of cruise ships. Employment of these specific volunteers by the incident commander (IC) should be encouraged, provided they fit into the Incident Command System (ICS). Medical personnel may provide assistance with the medical care, and ex-military may be asked to assist with the evacuation of other spectators by controlling certain areas of the scene and managing other volunteers.

- Transporters: Volunteers may help by carrying stretchers to ambulances or may assist walking wounded patients to get to the closest place where medical attention could be provided.

What not to do:

- Safety: The most important guideline is to assure the safety of the bystanders participating in the rescue efforts. If safety cannot be guaranteed, the employment of bystanders should be discouraged.
- Basic medical training: Volunteers should be allowed to manage injured patients only if they possess basic medical knowledge and training. Specifically, direct pressure on bleeding lacerations should be the only procedure performed by bystanders to control hemorrhage. Persons without training should not be allowed to place tourniquets or to use belts, cloths, and ropes as improvised tourniquets.
- Hospital staff going to the scene: Doctors and nurses should be discouraged to leave the hospitals to assist with the search and rescue efforts at the scene of the incident. This was one of the most important lessons learned from the Oklahoma City bombing.

Search and rescue is a profession that requires adequate knowledge and training and should not be performed by professionals who are not used to work in a field environment.

Regional Emergency Operations Center

In principle, the main function of a Regional Emergency Operations Center (REOC), from a medical perspective, should be to shorten scene time of the first responders by providing more assets such as ambulances and personnel when requested and coordinate the even distribution of patients among area hospitals.

In reality, the deployment of a fully staffed REOC (Fig. 2.5) is a time-consuming process and therefore has limited value in sudden mass casualty incidents (SMCIs). In an event where search and rescue is not needed and rapid evacuation of victims to hospitals is the main priority, waiting to staff the REOC will certainly delay patient transport and negatively impact their outcome.

FIG. 2.5. Fully deployed Regional Emergency Operations Center. Courtesy of FEMA Library

On the other hand, a fully operational REOC is of great value in sudden but protracted MCIs such as simultaneous attacks at various locations or where patients may be trapped in train cars or collapsed buildings and even more so during progressive disasters such as biological epidemics, hurricanes, and planned mass gatherings. In these situations, a fully staffed REOC should be operational and have the following responsibilities:

- Assist with the search and rescue, providing personnel and equipment as requested by the scene incident command (SIC).
- Coordinate patient transport to the right hospital as dictated by his medical condition.
- Avoid overcrowding area hospitals by evenly distributing the patients.

- Estimate when local hospitals are overwhelmed and coordinated external assistance.
- Coordinate inter-hospital transfers, according to medical needs of the patients and bed availability.

Prehospital Communications

During normal operations, radio communication in the prehospital environment is confined within the respective agencies, with distinct frequencies for police department (PD), fire department (FD), and emergency medical services (EMS).

In a sudden mass casualty incident (SMCI), there is a need for all first responders to communicate among themselves for better control and coordination at the scene. Yet, in a large-scale SMCI such as Madrid train bombing and September 11, 2001, attacks, where hundreds of first responders were involved, one radio frequency for all would have been disastrous.

Another important issue is despite the need to have individualized response planning for progressive disasters and SMCIs, there cannot be distinct radio frequencies for each of those types of events.

Therefore, the communication plan for a progressive disaster or for a SMCI should include the following circles of communication and should be applied in accordance to the type of event, the speed of its progression, and the deployment of a scene incident command (SIC) and a Regional Emergency Operations Center (REOC) or at the discretion of the incident commander (IC):

1. Two police frequencies:
   (a) Between all police cars and the police officer staffing the SIC
   (b) Between the police officer staffing the SIC and the police officer staffing the REOC
2. Two fire frequencies:
   (a) Between all fire trucks and the fire fighter staffing the SIC
   (b) Between the fire fighter staffing the SIC and the fire fighter staffing the REOC

FIG. 2.6. The scene in the aftermath of the Boston marathon bombing and the importance of having a common emergency channel among all first responders. Courtesy of Creative Commons

3. Two EMS frequencies:
   (a) Between all ambulances and the paramedic staffing the SIC
   (b) Between the paramedic staffing the SIC and the paramedic staffing the REOC
4. One common emergency channel (Fig. 2.6):
   (a) There should be one distinct frequency, to be used by all first responders during exceptional circumstances and at the discretion of the IC.
   (b) The emergency channel should be used during small-scale sudden events, when not many people are listening to this frequency or when an important message needs to be transmitted immediately and is relevant to all first responders.
   (c) The mechanism for all first responders to change from their specific frequency to the common emergency channel is to announce on their specific frequency that at a certain time (e.g., 10 am sharp) all vehicles need to change to the emergency frequency.

The communication plan should also include abbreviated communication codes to be spoken on the radio.

It is important to stress that radio communication *is not* a substitute for telephone and that strict radio discipline is vital.

Triage Hospital

Sudden mass casualty incidents (SMCIs) may occur in rural areas, where large medical centers or trauma centers may be far away. A good example is a train derailment outside major urban areas (Fig. 2.7).

Fig. 2.7. Train derailment in Macdona, Texas, June 21, 2004 (From Environmental Protection Agency)

"Triage Hospital" is a concept, not a building. This concept was developed for small community hospitals that happen to be the closest medical facility to the SMCI. Typically, it lacks major specialties such as neurosurgery and burns.

Since it is the only medical facility in the area, ambulances may, by default, transport patients to this hospital.

In principle, a "Triage Hospital" functions as a "resuscitation hospital." It performs all necessary procedures to stabilize the injured patient, including surgery for hemorrhage control, when indicated.

All patients, after initial stabilization, are transferred to higher-level medical facilities. Patients who underwent emergency surgery will remain at the community hospital until their condition is stabilized and then transferred to higher-level hospitals.

The switch of a community medical center from being an admitting hospital into a "Triage Hospital" requires a declaration by the hospital's CEO and communication to the Regional Emergency Operations Center.

The concept of a "Triage Hospital" should be part of the regional disaster plan.

Field Triage

The most clinically relevant definition of a sudden mass casualty incident (SMCI) is a "temporary state of insufficiency." From a prehospital perspective, it implies that in the first minutes after a SMCI, there may be insufficient number of ambulances, personnel, and equipment, limited access roads to the scene of the incident, and few evacuation routes for the ambulances to transport the injured patients. Therefore, a simple and rapid triage needs to be performed to ensure that the critical patients are identified, managed, and transported first.

The person that performs field triage (in different parts of the world, it could be a paramedic, EMT, or MD) needs to answer the three simple questions:

- Who needs immediate care in the field? (e.g., airway management)
- Who needs immediate transport? (e.g., internal hemorrhage that requires immediate surgical intervention)
- Who can wait? (e.g., mild injury or expectant)

Notes:

1. Not all patients who require immediate airway management need necessarily to be transported first!
2. The most important factor for the survival of a patient with internal hemorrhage is the speed to an operating room. Therefore, bleeding patients are the ones who should be transported first.
3. The labeling of the patients according to the severity of injury should be simple and fast and should not delay transport to hospitals.

The current acceptable triage categories are as follows (Fig. 2.8):

- Green: Minor injury – walking wounded
- Yellow: Delayed – serious and non-life threatening

FIG. 2.8. Example of a triage tag used at a field exercise. Courtesy of US Air Force

- Red: Life-threatening injury
- Black: Deceased

4. During transport to the hospital, the condition of the patient may deteriorate. Therefore, it is the important to perform additional triage upon arrival at the medical facility.

"Save and Run" in Mass Casualty Incidents

The concept of "Scoop and Run" in trauma care originated to address those patients with massive internal bleeding. It implies loading the patient to an ambulance, with minimal medical care at the scene, and transporting the patient, as quickly as possible, to an appropriate medical center, which can handle the injuries. In the USA, it is usually a level I trauma center.

Yet, other injuries are common after conventional sudden mass casualty incidents (SMCIs), in addition to internal bleeding. These include traumatic brain injury, tension pneumothorax, mangled extremities, and limb amputations.

In such situations, it becomes necessary to perform a few lifesaving interventions prior to or during transport.

These interventions include:

- Airway management and ventilatory support.
- Needle thoracostomy for tension pneumothorax.
- Tourniquet placement for extremity bleeding.
- Note: If necessary, IV should be inserted only during transport and *should not* delay patient evacuation.

This is the concept of "Save and Run," originally described by the Israeli EMS (Fig. 2.9), and implies performance of these few lifesaving procedures prior or during transport.

Distribution of Patients between Hospitals and Prehospital Patient Tracking

There are a few important topics to consider when distributing patients between hospitals after a sudden mass casualty incident (SMCI):

Fig. 2.9. Israeli EMS (MDA) at the scene of an MCI

- Clinical diagnosis of the patient
- Specific injuries: Traumatic brain injury (TBI), vascular injury, and burns
- Clinical capabilities of the hospitals in the area of the SMCI
- Total number of injured to be evacuated
- Number of critical patients
- Number of ambulances available
- Number of helicopters available
- Distance of the local and regional hospitals to the incident
- Avoidance overwhelming hospitals
- Use of "Triage Hospital" concept (page 17)

There are two types of methods for distribution of patients between hospitals:

- **Primary distribution**: **The patient is primarily transported to the definitive hospital, with specific injuries transported to hospitals with adequate capabilities** (Fig. 2.10).

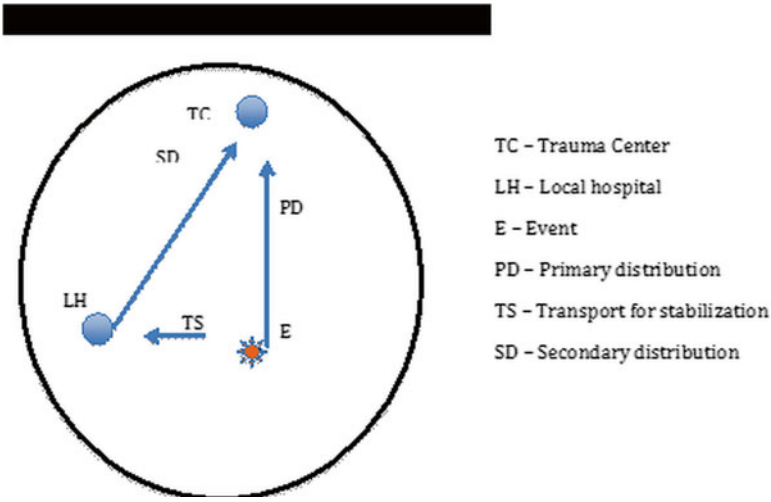

FIG. 2.10. Primary versus secondary distribution

This is the preferred method and the best for the patient, since it provides the shortest time to definitive care.

Nevertheless, if the definitive hospital is far away from the event, it may require **many ambulances**, which may not be available, at least during the initial phase of a SMCI.

The presence of **helicopters** may facilitate and expedite the transport of critical patients or specific injuries to definitive hospitals and allow the ambulances to perform short transport rounds to local hospitals.

- **Secondary distribution**: **The patient is transported to the nearest hospital** ("Triage Hospital") **and after stabilization is transferred to the definitive hospital** (Fig. 2.10).

With this method, ambulances will perform short transport rounds and will evacuate a larger number of patients in a shorter period of time, but it will delay definitive care for the patients with specific injuries.

In addition, **secondary distribution** of patients requires a large number of ambulances and is associated with the huge logistical challenge of inter-hospital transport. In this situation,

the involvement of the Regional Emergency Operations Center (REOC) is imperative.

Note:

In a large-scale **urban SMCI**, where one or more trauma centers may be close to the event, it is possible to use large helicopters (military) to distribute the mildly injured patients (which account for the vast majority) to distant hospitals rather than to the trauma centers in the area. This concept has two benefits:

- Allow the trauma centers to focus their efforts on the critically injured.
- Reduce the risks of air transport of critically injured patients.

The decision about the preferred method of patient distribution is the responsibility of the incident commander in coordination with the REOC, with the above considerations.

Prehospital Patient Tracking

Large-scale urban SMCIs are overwhelming events to any city. The initial chaos may be longer than expected. Control and coordination between ambulances may be lacking. Consequentely, change in ambulance destination after leaving the scene is common.

Therefore, the use of prehospital patient tracking devices, such as barcode scanners, will not only delay patient evacuation but may be inaccurate, causing confusion to incident managers and families.

Tracking of patients is important but should be used, almost exclusively, at the hospitals.

Difference between Urban and Rural Sudden Mass Casualty Incidents

Urban

- Trauma centers immediately available
- Larger number of ambulances readily available
- Scarce use of air transport
- Most common method of patient distribution: Primary (page 21)

Rural

- Longer time to definitive care and to trauma centers.
- Few ambulances available requiring mobilization of ambulances from other counties.
- Air transport is usually needed for critical patients.
- Most common method of patient distribution: Secondary (page 22).
- The use of the "Triage Hospital" concept is common.

3 Hospital Planning and Response to Sudden Mass Casualty Incidents

Essential Components of a Sudden Mass Casualty Incident Plan

The differences between progressive disasters and sudden mass casualty incidents (SMCIs) were addressed earlier (pages 3, 4).

From a medical perspective, there are many clinical, logistical, and organizational differences between the various types of progressive disasters and SMCIs; therefore, detailed planning should be specific for each type:

- Conventional/burn MCIs
- Chemical/toxicological MCIs
- Radiation incidents
- Biological disasters

Plan activation should be identical for weekdays, weeknights, weekends, and holidays.

A hospital plan for a SMCI should include the following components:

1. Strategies to prevent patients flooding the hospital
2. Surge capacity specific for the hospital: The resources (staff, space, supplies) needed to manage a sudden surge in the number of patients, above its normal capacity

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3. Methods for call-in of additional personnel
4. Organization of treatment areas
5. Opening and organization of alternate treatment sites
6. Deployment of additional equipment and supplies to existing and alternate treatment sites
7. Hospital communication plan
8. Methods for identification of patients, registration, and patient tracking
9. Individualized plan for respiratory therapy, blood bank, laboratory, and radiology
10. Organization of a family information center
11. Activation of the SMCI plan and hospital response
12. Triage and principles of medical care during a SMCI
13. Planning and activation of hospital decontamination for chemical exposure

Hospital Surge Capacity Calculation

Assumptions and Definitions

Hospital planning for sudden mass casualty incidents (SMCIs) and disasters assumes that the hospital is at full capacity, including the emergency department and the intensive care unit(s).

Hospital surge capacity (HSC) is the acute augmentation of its capacity to receive and manage victims of a SMCI.

The components of HSC are additional **staff**, alternate **space**, and extra equipment and **supplies**.

The importance of computing HSC specific to each medical center is to have an estimate of the maximal number of additional patients to be treated at the institution and consequently the number of additional personnel, critical equipment, supplies, and stretchers (which will be used as additional beds) that need to be deployed after a SMCI is announced.

Obviously, a 500-bed hospital will have a different surge capacity than a 1000-bed hospital.

Maximal Number of Patients (MNP) per Hospital

The estimated maximal number of patients to be treated at any given hospital during a SMCI is approximately 20 % of the total bed capacity of the hospital.

Example: A **hospital with 500 licensed beds will manage up to 100 patients.**

Up to 20 % of all victims are expected to be pediatric patients.

Up to 30 % of patients are expected to have different degrees of post-traumatic stress disorder (PTSD) separate or in conjunction to conventional injuries.

Distribution of Victims by Severity

For planning purposes, it is assumed that the maximum number of **critical** patients that could be treated at any hospital should not exceed 20 % of MNP. This number has important implications in terms of additional personnel, critical equipment (such as ventilators), and number of extra stretchers (used as temporary extra beds) needed to manage the sudden surge of patients.

Table 3.1 summarizes the distribution of patients, by severity, to be treated at any medical facility after a SMCI.

Example: A hospital with 500 licensed beds will manage up to 20 critical patients.

A hospital plan for a SMCI needs to identify areas in the emergency department or other alternate sites, to concentrate patients by severity. A medical director needs to be appointed for each site.

Table 3.2 summarizes the number of personnel required to manage patients from a SMCI, according to severity. A hospital is required to have an emergency call-in list to bring back critical personnel if a SMCI occurs after hours, on weekends or holidays.

TABLE 3.1. Distribution of injuries by severity

Severity	**% of MNP**
Red – Critical and life threatening	20
Yellow – Severe, non-life threatening	30
Green – Walking wounded	50

TABLE 3.2. Personnel planning for ED intake, initial evaluation, and management

Personnel/staff	Triage	Red	Yellow	Green	Mental	Pediatrics
Attending/fellow[a]	1	1	1	1	1	1
Physician/patient ratio (MD)		1/1	1/10	1/10	1/3	1/10
Nurse/patient ratio (RN)	2 RN	1/1	1/5	1/5	1/3	1/5
Respiratory therapist (RT)	n/a	1/4	n/a	n/a	n/a	n/a
Escort/patient ratio (ES)	1/10	1/3	1/10	1/10	1/10	1/10
Clerk/patient ratio (CL)	1–2 CL	1/2	1/5	1/5	1/5	1/5
Radiology technicians (RD)	n/a	1/5	1/10	1/10	n/a	1/10
Blood bank runners (BB)	n/a	1/10	1/20	n/a	n/a	n/a
Security guards (SG)	5–10	1	1	1	1	1
Administrator[b] (AD)	1	1	1	1	1	1

[a]Attending/fellow relates to teaching hospitals
[b]Assists the treatment site medical director with administration and logistics

Example: In the first hour, a hospital with 500 licensed beds will need to have available approximately:

- **Twenty doctors**
- **Twenty nurses**
- **Five respiratory therapists**
- **Ten escorts**
- **Ten clerks**
- **Five radiology technicians**
- **Two blood bank technicians**
- **Ten security guards**
- **Three administrators**

The purpose of the above personnel is to triage, transport, register, evaluate, and manage the initial flow of patients. The priority is to manage the critical (Red) patients first!

Approximately 10 % of the Red patients from a conventional SMCI will require emergent lifesaving surgery. Half of those will require hemorrhage control for internal bleeding; the other half will require neurosurgical interventions.

Example: A 500-bed hospital will manage up to 20 Red (critical) patients, of which about two will need emergency life-saving surgery (10 % of 20). Therefore, this hospital will need to have available two immediate operating rooms, one general/trauma surgery team, and one neurosurgical team. Limb hemorrhage could be managed with tourniquets until more staff and operating rooms become available.

A significant number of patients will require one or more surgical interventions during their hospital stay. These procedures are considered urgent.

Table 3.3 shows the approximate percentage of victims who will require urgent surgery by specialty.

Table 3.4 summarizes the total amount of critical equipment and supplies necessary, as function of the MNP, to manage a SMCI at a 500-bed hospital.

Table 3.3. Approximate number of urgent operations, as function of the MNP

Operation	% of MNP
Open fractures	10
Penetrating eye injuries	5
Neurological (urgent)	10
Chest	5
Oral/maxillary/facial	5–10
Burns	5–10

Table 3.4. Critical equipment/supplies planning

Equipment	% of MNP
Stretchers	35 (% of reds + ½ of yellows)
Wheelchairs	65 (% of green + ½ of yellows)
Ventilators	20 (% of reds)
Cardiac monitors	35 (% of reds + ½ yellows)
Pulse oximeters	20 (% of reds)
Trauma carts (each cart for 20 patients)	# of carts = MNP – ED capacity/20
ICU carts (each cart for 20 patients)	# of carts = # of reds/20
Color-coded identification vest	300 vests for a 500-bed hospital

Treatment Areas, Alternate Sites, and Deployment of Extra Equipment and Supplies

Principles:

- In a sudden mass casualty incident (SMCI), there may be insufficient space to manage the abrupt surge of patients.
- It is important to concentrate patients, according to severity, in one area.

- In addition to the treatment areas in the emergency department (ED) or trauma center (TC – if applicable), there is a need to designate alternate treatment areas to cope with the sudden increase of patients.
- The number of alternate treatment areas will be in accordance to the calculated maximal number of patients (MNP) specific for the hospital (see Hospital Surge Capacity Calculation).

Designated treatment areas:

- Red:
  - ED
  - Trauma center (if applicable)
- Yellow:
  - ED
  - Alternate site (hospital lobby, ambulatory care center)
- Green:
  - Alternate site (hospital lobby, ambulatory care center)
- Pediatric patients (Yellow or Green):
  - Pediatric ED (if applicable)
  - Alternate site
- Mental health:
  - Ambulatory care center
  - Alternate site
- Alternate intensive care unit (ICU):
  - Operating room recovery

Sources of personnel for treatment areas:

- Regular ED or TC personnel
- Call-in personnel
- ICU nurses from ICU(s)
- Total amount of personnel required will be a function of severity (see Hospital Surge Capacity Calculation)

Equipment and supplies:

- Stretchers will serve as extra beds in the ED, TC and at the alternate treatment sites.
- Trauma carts (each cart for 20 patients).
- ICU carts (each cart for 20 patients).

- Extra ventilators.
- Communications (as per hospital communication plan – see below).

Hospital Communications during Sudden Mass Casualty Incidents

Assumptions

During a sudden mass casualty incident (SMCI), there is a need to have flow of information to and from the hospital and within the hospital simultaneously.

Landlines may be affected during flooding and overwhelmed during a SMCI; therefore, there is a need for other means of communication.

Utilization of personal cell phones may be an option. Nevertheless, depending on the carrier, signal strength may vary within the hospital. In addition, cellular towers may be affected during earthquakes.

Therefore, handheld professional **two-way radios** may be an excellent alternative (Fig. 3.1).

Channels (frequencies):

At least two communication channels should be available at the hospital:

1. Security channel
2. Medical channel

It is important to have a distinct **medical channel** to communicate between the important areas of the hospital with respect to patient care and logistics:

- Triage area
- Treatment sites in emergency department (ED) and trauma center (TC)
- Operating room
- Respiratory therapy
- Transport
- Blood bank
- Radiology
- Laboratory
- Security

FIG. 3.1. Portable radios being distributed during an MCI drill

- Command center
- Family information center

Below is a suggested list of functions that need to be on the medical frequency:

1. Hospital disaster manager/representative
2. Surgeon in charge of the event (for conventional SMCI)
3. Radiology supervisor
4. Respiratory supervisor
5. Clerk supervisor
6. Patient staging supervisor
7. Triage officer
8. ED medical doctor in charge
9. ED charge nurse
10. Pediatric ED medical doctor in charge (where applicable)
11. Pediatric ED charge nurse (where applicable)
12. Medical director of the *red* treatment area
13. Medical director of the *yellow* treatment area
14. Medical director of the *green* treatment area
15. "Operating room priority" surgeon
16. Senior anesthesiologist on call

17. Blood bank
18. Transport supervisor
19. Social services/family information center
20. Trauma center head/charge nurse (where applicable)
21. Incident command center
22. Supervisor at personnel meeting point (physicians and nurses)

The communication plan should also include abbreviated communication codes to be spoken on the radio.

It is important to state that radio communication *is not* a substitute for telephone and to have a strict radio discipline policy.

Activation of a Mass Casualty Plan

Activation:

In principle, the activation of a sudden mass casualty incident (SMCI) plan must be simple and systematic, based on pre-prepared checklists.

- Notification:
- The notification that a possible SMCI has occurred will be to the emergency department (ED) or trauma center (TC) through one of the following ways:
  - Fire rescue/police radio
  - Direct land phone lines to the ED/TC
  - Through hospital operator
  - News media
  - First victim or person arriving to the ED from the scene
  - From hospital security

Once the notification is received in the ED/TC, a brief discussion between the senior surgeon on call, the ED senior physician, and the ED/TC charge nurse should occur to assess the situation and decide whether to activate the MCI plan.

- Verification:
  - Verify if the event is real – call back the Regional Emergency Operations Center (REOC)/EMS/police/fire.

  - Verify type of event: conventional/chemical/radiological ("dirty bomb").
  - Discuss event with ED physician/surgeon in charge and ED/TC charge nurse.

- Approval to activate MCI plan:
- The formal activation of the MCI plan requires approval of the chief executive officer (CEO) of the hospital or his designee.
  - Call the CEO/COO/CMO/CNO/executive on call to approve activation of MCI plan.
  - Once activation of the MCI plan is approved, the senior surgeon, ED senior physician, and the ED/TC charge nurse will simultaneously complete their respective checklists, assuring maximal coordination.

- Senior surgeon/ED physician in charge checklist:
  - Activate in-house and call-in lists (if necessary, as function of magnitude of the event).
  - Get your designated portable radio.
  - Verify with ED/TC charge nurse the creation of spaces in ED and alternate care sites.
  - Notify the operating room (OR) and cancel scheduled, non-urgent operations.
  - Verify that security, respiratory therapy, blood bank, radiology, laboratory, and mental health were notified.
  - Activate triage site: Designate appropriate triage physician (surgeon/ED physician) according to availability.
  - Debrief arriving personnel about the event and briefly describe management strategies.
  - Designate medical teams: one MD and one RN per patient for each Red patient.
  - Designate OR teams, as calculated by hospital size (OR team = one surgeon or neurosurgeon, one surgical or neurosurgery assistant, one anesthesiologist, one anesthesia assistant, two OR nurses).
  - Designate "OR priority surgeon" (does not scrub). Once "OR priority surgeon" arrives, he/she takes charge of designating OR teams and prioritizing emergency operations.
  - Distribute call-in physicians, together with ED charge nurse, to form medical teams with nurses.

- Designate administrative assistant to follow you (to hold your radio, update you about number of casualties, including age and severity).
- Communicate frequently and update the hospital incident command center (phone/radio).
- Perform frequent debriefings to the entire workforce about the magnitude of event and changes in management strategies (if applicable). Dismiss unnecessary personnel.

- ED head/charge nurse checklist:
  - Notify security.
  - Activate overhead paging system (if available).
  - Activate call-in lists (if necessary, as function of magnitude of the event).

    Activate the disaster paging system/communicator.

  - Call ICU nurses to meeting point.
  - Call all doctors in house to meeting point.
  - Activate the emergency stretcher plan. Twenty stretchers and 20 wheelchairs immediately to triage area (Page 40).
  - Empty ED (ventilated patients *are not* moved to alternate sites).
  - Notify and verify creation of spaces at alternate care sites.
  - Notify OR.
  - Notify blood bank (phone/radio), radiology (phone/radio), laboratory (phone/radio), and mental health (phone/radio).
  - Activate emergency equipment plan:

    Move additional ventilators to "ventilator concentration point."
    Move trauma carts to ED/alternate care sites.
    Move ICU carts to preplanned alternate ICU sites.

  - Debrief arriving nurses about event and management plan.
  - Distribute identification vests and radio communications.
  - Form medical teams for arriving victims: One MD and one RN for each Red patient (team 1, first arriving patient; team 2, second arriving patient; etc.).
  - Distribute call-in arrivals (MDs and nurses arriving from home).

Call-in of Essential Personnel in a Sudden Mass Casualty Incident

The most important component of hospital surge capacity is the ability to match the abrupt surge of patients during a sudden mass casualty incident (SMCI) with the adequate amount of essential personnel:

- Doctors
- Nurses
- Respiratory therapists
- Radiology technicians
- Laboratory technicians
- Blood bank technicians
- Clerks
- Transporters
- Security guards

During slow progressive disasters, approaching hurricanes, and planned sporting events, there is time to increase the amount of personnel needed to respond to a potential increase in the number of patients.

Nevertheless, in a SMCI, where the surge of patients is abrupt and without previous notice, acutely increasing the amount of personnel may be a true challenge.

Therefore, a hospital needs to have redundant methods to rapidly and efficiently call-in personnel, once the hospital's SMCI plan is activated.

The source of additional personnel may be from:

- Within the hospital
- Home

Methods for call-in of personnel:

- Overhead paging system for the entire hospital
- Alphanumeric paging system
- Web-based "communicator" system

Note: "Call-in tree" – This method assumes the listed people are in town and will answer their phone. While adequate for progressive disasters, it should not be used as the main call-in process for SMCIs.

Identification badges:

- All personnel called from home need to have their identification badges at all time, to facilitate driving through police checkpoints.

Parking:

- The call-in plan should include a predesignated parking area in an event that there is a need for extra parking space for the personnel arriving from home.

Meeting points:

- The call-in plan should include a designated meeting point for call-in of personnel. Its location should be in accordance to the specific function:
  - Clinical personnel should meet close to the treatment sites.
  - Respiratory therapists should meet where the ventilators are stored.
  - Radiology technicians should meet where the portable X-ray machines are stored.
  - Blood bank and laboratory technicians should meet at the laboratory.
  - Transporters/escorts should meet where the extra stretchers/wheelchairs are stored.
  - Registration clerks should meet at the administration offices.

Hospital Strategies to Prevent Flooding of Patients

It is possible that after a sudden mass casualty incident (SMCI), a large number of walking-wounded or mildly contaminated patients that are frightened and panicked may attempt to burst into the hospital, despite all security measures.

After the Tokyo subway attack with sarin gas in 1995, 82 % of contaminated patients arrived at the hospitals driven by private cars, with consequent contamination of 25 % of the hospital staff.

Hospitals need to have a means to prevent uncoordinated flooding of patients as they may further contaminate unprotected hospital personnel.

Potential solutions:

- Security guards: It is highly unlikely that security guards will be able to contain hundreds, if not thousands, of panicked individuals attempting to enter the hospital.
- Perimeter fence: A physical barrier, surrounding the entire medical center, is probably the best solution for prevention of patients flooding the hospital. The perimeter fence should have gates, which would remain open during normal hospital operation and can be quickly closed when the threat for a sudden overflow of patients exists (Fig. 3.2).
- The closure of the gates should be the responsibility of the chief of security of the hospital. After construction of the fence is completed, it is recommended to perform a few drills to familiarize the security guards with the procedures required to close the gates after the notification that a SMCI has occurred (Fig. 3.3).

FIG. 3.2. Gated perimeter fence, protecting a large medical center in Miami, FL

FIG. 3.3. Exercise to familiarize security guards with gate closure procedures

Hospital Response: Preparation of Triage Area and Emergency Department

Immediately after approval to activate the sudden mass casualty incident (SMCI) plan, the hospital initiates its response to the incident.

The first priority is to prepare the triage area outside the emergency department (ED) and create space inside the ED for the incoming critical patients. Preferably, these processes should be performed simultaneously:

1. Preparation of "stretcher concentration point":

   (a) Transport (escort) supervisor will distribute transporters (escorts) to the triage area and ED and perform the following actions:

   - Deploy escorts to help create spaces in the ED.
   - Deploy escorts to open the stretcher storage (Fig. 3.4) and distribute the stretchers to the "stretcher concentration point," in proximity to the triage area, outside the ED (Fig. 3.5).

Fig. 3.4. Stretchers and wheelchairs storage located next to triage area

Fig. 3.5. Stretcher concentration point located next to the triage area

- Escorts will bring all empty stretchers/wheelchairs from ED to the "stretcher concentration point" in proximity to the triage area, outside the ED (Figs. 3.6 and 3.7).

- At the "stretcher concentration point," the escort supervisor will have radio communications, *on medical frequency*, with all treatment areas. He/she will deploy escorts according to demand.
- A voice amplification device should be used to facilitate control of the area.

2. Preparation of triage area:

   (a) Personnel (Fig. 3.8):

   - Triage physician: surgeon/ED physician
   - Two RNs from ED
   - Three or more clerks for quick patient registration, photography, and severity labeling according to the triage physician

   (b) Equipment/supplies (Fig. 3.8):

   - Colored charts and armbands: The total number of charts and armbands will be determined according to the total

FIG. 3.6. Escorts at the "stretcher concentration point" showing stretchers

FIG. 3.7. Escorts at the "stretcher concentration point" showing wheelchairs

FIG. 3.8. Personnel and supplies at the triage area

number of patients expected to be managed at the institution. The number of "red," "yellow," and "green" charts and armbands is according to the expected number of patients and their severity (page 27). The charts and armbands should have predetermined registration numbers. The charts should include basic documentation forms: rapid medical assessment, X-ray, and blood bank. No written documentation will be performed at triage area but only the categorization of severity.

- Digital cameras should be used by one of the registration clerks to photograph comatose patients or infants. The temporary medical record number (T-number) should be included in the picture.
- A voice amplification device should be used by the triage physician/nurse to facilitate control of the area.
- ED administrator, in consultation with triage nurse manager, is responsible for ensuring that supplies at the triage area are ready and available.

3. Evacuation of ED:

(a) Simultaneously, the surgeon in charge and the ED physician will make decisions with regard to those patients who can be safely moved to other treatment areas:

- Ventilated patients in the ED will be transferred out only if an ICU bed is available.
- Patients from the ED area will be moved to available beds in the hospital. If no beds are available, patients will be placed in corridors, under nursing/medical supervision as needed.
- Medically stable patients in the ED, identified by a physician and charge nurse, will be transported to preplanned alternate care areas. This space will serve as a staging area until floor beds are available. All patients will remain under nursing/medical supervision, as needed.
- ED surge capacity is based on availability of extra medical staff and space for the incoming patients, which will be transported to the ED on stretchers or wheelchairs from the triage area.

4. Preparation of ED and in-hospital treatment sites:

   (a) Treatment areas for Reds:

   - All critical patients will be treated in the TC (where applicable) or designated areas in the ED. In case there is a need for more space for critical patients, alternate treatment sites should be opened, such as operating room recovery or another preplanned locations.
   - The surgeon in charge of the Red treatment area is the senior surgeon on call. Other surgeons/doctors will be assigned as they arrive and become available. Nurses will be assigned as they arrive from other hospital areas or from home.
   - Communications: Radio on medical frequency for surgeon in charge and nurse in charge of the site.
   - Equipment: The standard equipment and supplies for trauma care already present in the ED will be used and supplemented by "trauma carts" as needed (page 30).

   (b) Treatment areas for Yellows:

   - Yellow patients will be treated at designated areas in the ED.
   - The surgeon/doctor in charge of the Yellow treatment area is another surgeon, if available or ED doctor. Other surgeons/doctors will be assigned as they arrive and become available. Nurses will be assigned as they arrive from other hospital areas or from home.
   - Communications: Radio on medical frequency for surgeon in charge and nurse in charge of the site.
   - Equipment: The standard equipment and supplies for trauma care already present in the ED will be used and supplemented by "trauma carts" as needed (page 30).

   (c) Treatment areas for Greens:

   - Green patients (the majority of the victims) will be treated at ambulatory care centers or other preplanned areas of the hospital. Walking wounded patients should *not* be allowed in the ED, until a complete assessment of total number of patients that could potentially be transported to the hospital is performed at the scene.
   - Usually, there is no need for stretchers for these patients; they can sit in a chair or wheelchair and wait for their turn to be examined.

- The doctor in charge of the Green treatment area is an ED doctor on call. Other doctors will be assigned as they arrive and become available. Nurses will be assigned as they arrive from other hospital areas or from home.
- Communications: Radio on medical frequency for doctor in charge and nurse in charge of the site.
- Equipment: "Trauma carts" will be distributed as needed (page 30).

(d) Pediatric patients:

- Pediatric patients of conventional SMCI will be treated in the trauma center (where applicable) or the pediatric ED (where applicable) according to severity of injuries.
- The Pediatric surgeon on call (where applicable) is in charge of the Pediatric treatment area. Other surgeons/doctors will be assigned as they arrive and become available. Nurses will be assigned as they arrive from other hospital areas or from home.
- Communications: Radio on medical frequency for surgeon in charge and nurse in charge of the site.
- Equipment: The standard equipment and supplies for trauma care already present in the pediatric ED will be used and supplemented by "trauma carts" as needed (page 30).

(e) Mental health triage (MHT):
Patients demonstrating signs and symptoms of behavioral health concerns will be treated at the preplanned site for mental health victims.

- The physician in charge of MHT is the psychiatrist/psychologist on call (where applicable).
- Specific equipment, supplies, and drugs for mental health patients to be distributed as needed.

(f) Operating room (OR):

- The first patient who requires resuscitative surgery will be transferred to the OR, assuring there is adequate staffing.
- The surgeon in charge in the OR is one of the surgeons called in from home. His/her function is to be the "OR priority" surgeon. He/she will not scrub, unless he/she is

absolutely needed. His/her function is to prioritize patients requiring emergent/urgent operations among the requests from various services.

- Emergency surgery priorities:
  - Life threatening:

    Internal hemorrhage with hemodynamic instability
    Intracranial hematoma

  - Limb/organ threatening:

    Vascular injury
    Penetrating eye injury

  - Other priorities:

    Peritonitis
    Open fractures
    Burns

- Communications: Radio on medical frequency for "OR priority surgeon" and OR charge nurse. Intercom and telephones could be used if available.
- Personnel: It is the responsibility of OR supervisor/charge nurse to have OR staff for the approximate number of resuscitative operations calculated within 30–60 min from event announcement (page 29).
- Supplies: It is the responsibility of OR supervisor/charge nurse to have surgical supplies immediately available for the approximate number of resuscitative operations calculated within 30–60 min from event announcement (page 29).

(g) Intensive care units (ICU):

- Patients who require ICU beds will be admitted according to bed availability.
- Alternate ICU beds need to be available.
- Personnel: Available nurses from other intensive care units need to be redistributed by the hospital head nurse/designee, until arrival of ICU nurses called in from home.
- Equipment and supplies: Ventilators and ICU carts at alternate sites to be distributed as needed (page 30).

(h) Respiratory therapy:

- Immediately after event announcement, the respiratory supervisor in house should deliver five ventilators to the "ventilator concentration point," usually located in proximity to the ED/TC.
- Other ventilators will be distributed to the treatment sites as needed.
- Communications: Radio on medical frequency for the respiratory supervisor.

(i) Registration:

- The clerk supervisor should deploy all clerks available in the hospital to the treatment sites as soon as the MCI plan is activated.
- Communication: Radio on medical frequency for the clerk supervisor.

Hospital Response: Identification, Registration, Triage, and Inflow of Patients

The early stages of a sudden mass casualty incident (SMCI) are characterized by confusion and lack of command and control. It is called the "chaos" phase (page 7).

Misidentification of patients may occur.

It is critical that a hospital has a mature identification and registration system, for multiple simultaneous patients, and that could be easily accessed when tracking of patients is required by family members looking for their loved ones.

1. Unloading of patients from ambulances to hospital stretchers:
   Transfer of patients from ambulances to hospital stretchers in a SMCI should occur at the triage area, not inside the ED/TC.
2. Identification:
   Identification of comatose patients and/or infants should start at the triage area of the hospital. For this purpose, **cameras** should be used to photograph the face of the arriving patient together with the T-number associated with the appropriate colored chart. The pictures should be stored in a specific digital folder connected to the hospital information system (HIS) of the hospital.

Pictures of unidentified patients are then shown to family members at the family information center (FIC) (page 52).

3. Registration:
   Simultaneous registration of multiple patients during a SMCI is a real challenge but nevertheless of critical importance. It is common to misidentify comatose patients or infants that were close to other victims or may have been in possession of bags or wallets of their friends when the event occurred.

   When planning for a SMCI, it is important to plan for enough clerks to register multiple injured simultaneously during the influx of patients. To calculate the specific number of clerks for a given hospital, please see Hospital Surge Capacity Calculation (page 28).
4. Triage:
   Triage of patients outside the ED is a quick process, less than 1 min long, to evaluate the patient and decide the severity and destination.

   Critical (Red) Patients are those who sustain one or more of the following life-threatening conditions:

   - Respiratory distress
   - Shock
   - Coma/altered mental status
   - Amputations

   Minimal medical care is provided at the triage site:

   - Ventilatory assistance with Ambu bag (if necessary)
   - Tourniquets for exsanguinating limb hemorrhage

5. Inflow of patients:
   After a brief triage, a colored chart and armbands, both matching patient severity ("red" chart to "red" patient), will be attached to the patients on stretchers or in wheelchairs. The transporter will then follow preestablished pathways for patient influx, identified by direction arrows on the corridor floor or walls. The selected pathway (arrow color) should match the color of the chart on the patient. This system simplifies patient transport from the triage area to in-hospital treatment sites and increases the likelihood of correct patient disposition, as determined by the triage physician.

The Medical Care Philosophy during a Sudden Mass Casualty Incident

After triage is completed, patients are distributed to the treatment sites according to the severity of injury. The medical philosophy in a sudden mass casualty incident (SMCI) is different when compared to the management of a single trauma patient.

1. Principles of medical care inside the treatment sites:

- Salvageable critical (Red) patients are treated first!
- Traumatic injuries should be managed following ATLS® guidelines.
- The medical care for nonemergent patients should be delayed until more medical personnel become available.
- In all treatment areas, the surgeon in charge/ED physician is the one responsible for the care of the patient. All major decisions such as priorities of care and disposition (OR, radiology, ICU, or floor admission) are made by the surgeon in charge/ED physician.
- No patient should leave treatment site without approval of the surgeon in charge/ED physician.
- Once the patient leaves the treatment site area, the patient does not return to the same area. Therefore, decisions regarding disposition of the patient should be made before the patient leaves the treatment site or in the radiology suite (e.g., a neurosurgeon should be in the CT scan, making immediate decisions).
- Blood bank:
  - Blood type and cross match (T + C) is of critical importance for the management of a trauma patient. In a SMCI, expect multiple requests for type and cross simultaneously. In principle, T + C is one of the two laboratory tests to be performed in the initial phase of a MCI. The other is arterial blood gas.
  - Automated systems to transport blood samples from the emergency department (ED) or trauma center (TC) may be overwhelmed in a SMCI. Therefore, to be able to expedite transport of blood samples and avoid misidentification, "blood bank runners" should be utilized.

  - The main function of the "blood bank runners" is to collect the tubes and bring them to the blood bank. They should also distribute the blood and products to the sites where needed.
  - The blood bank supervisor should be in direct radio communication with sites, where more commonly blood will be needed: treatment area of the Red patients, operating room, and intensive care unit.
  - Communication: Radio, on medical frequency, for the blood bank supervisor.

- Laboratory:
  - Blood tests routinely performed in a single trauma patient should not be performed in a SMCI. Laboratory technicians most certainly will be busy performing T+C and emergency blood tests such as arterial blood gases (ABG) and hemoglobin levels.
  - It will be at the discretion of the treating physician to order other tests.

- Radiology:
  - Imaging should be scarce during the initial phase of a SMCI and limited only to examinations that will have an absolute impact on patient management.
  - CXR and pelvic X-rays should be performed at the treatment site with portable X-ray units.
  - Ultrasound (US) or diagnostic peritoneal lavage (DPL) should be used when intra-abdominal bleeding is suspected.
  - Computerized tomography (CT) is used in the initial phase of a SMCI only for patients with suspected traumatic brain injury (expect multiple brain CT scans to be performed in the first hours).
  - Limb X-rays will only be performed for open fractures and/or for limb-threatening injuries.
  - Immobilization of the limb/s for clinically suspected fractures should be performed; X-rays for closed fractures should be delayed.

Family Information Center, Tracking of Patients, and Media Relations in a Sudden Mass Casualty Incident

1. Family information center (FIC):
   There is a need to identify an area of the hospital to accommodate a sharp increase in the number of family members seeking information about their loved ones. At least three family members for each patient are expected to arrive.
   The basic planning of an FIC includes:

   - Personnel:
     - One psychologist
     - Social workers
     - Clerks
     - Medical doctor (if available)
   - Equipment:
     - Computer monitors connected to hospital information system to show pictures of unidentified patients to people searching for missing family members.
   - Facilities/supplies:
     - Public phones
     - Toilets
     - Food/drinks

2. Tracking:
   Tracking of patients in the community where the SMCI occurred is important and needs to be performed at the hospital level. All Israeli hospitals have one secure tracking program (ADAM) that can be accessed at any hospital in the country. Since the patients from a SMCI may be transported to any hospital in the city, this program prevents family members from traveling from one hospital to another in search for their loved ones. Instead, this database may be accessed at the first hospital where they arrive. If the missing family member could not be found at the first hospital, family members could then see pictures of unidentified patients at all the hospitals in the city.
   Prehospital tracking, although being recently tested, may be challenging in a SMCI and should not be used (page 23).

3. Media center:
   In general, media coverage of a SMCI starts simultaneously with patient care. Reporters need a designated working area. In addition, they need to be provided with timely and updated information. A designated public relations officer of the hospital should have specific training to address the media.

   The hospital experiencing a SMCI should use the media for its own benefit: Early broadcasting of a hospital "hotline" number is of critical importance to reduce stress and anxiety of family members and friends who are eager to know the destiny of their loved ones. Media should also be used to broadcast essential instructions to the population such as evacuation routes, safety instructions, public warning, public reassurance, and the stimulation of aid and donations both locally and beyond. These potential benefits are instrumental in disaster management, and therefore, excellent relations between the media and medical services are essential. This is the responsibility of the public relations officer, who should use all forms of media (television, radio, print, and Internet) to disseminate relevant event-related information.

Hospital Incident Command in a Sudden Mass Casualty Incident

The well-known *Hospital Emergency Incident Command System* (HEICS), first published in the mid-1980s, is the "brain" of the hospital during a disaster, and it provides a clear chain of command.

The structure, function, and operability of HEICS may be found elsewhere.

This section will discuss a different approach for a hospital incident command (HIC), which is more appropriate for sudden mass casualty incidents (SMCIs).

The use of the formal HEICS is one of the best examples why the classification of disasters into progressive and sudden is important (page 3).

A fully deployed HEICS should be very beneficial for the hospital during a slowly developing biological epidemic, when tracking a hurricane for a few days or for a planned mass gathering such a

large sporting event. In these situations, there is enough time to schedule the key personnel listed in the HEICS table of organization while verifying that they are actually available.

Because of its unexpected nature and the fast speed of its progression, the use of a fully deployed HEICS in a SMCI is questionable at best. The HIC during the first hours of a SMCI should be distinct and include with the following features:

- Simple
- Based on the personnel on call at the hospital
- Identical for weekdays, weeknights, weekends, and holidays
- Mobile
- Flexible
- Expandable

As discussed previously, the initial hospital phase of the SMCI includes various stages, most of which are simultaneous:

1. Preparing the triage area:
   (a) Deployment of stretchers, wheelchairs, medical equipment, identification and registration supplies, medical personnel, transporters, and security
2. Preparing space in the emergency department (ED):
   (a) Outflux of patients, movement of empty stretchers to triage area
   (b) Absorption of additional medical and support personnel
3. Preparing alternate sites of medical care:
   (a) Deployment of stretchers, equipment, ventilators, and supplies
   (b) Absorption of additional medical and support personnel
4. Preparing operating rooms:
   (a) Scheduling surgical teams
   (b) Deployment of additional equipment

5. Influx of patients:
   (a) Triage
   (b) Transport to treatment sites, CT scan, operating rooms, and intensive care units
   (c) Deployment of additional equipment and supplies to treatment areas as needed

To control all these simultaneous stages, simplicity of an HIC is key! There is no time to wait for administrators to arrive from home; therefore, the HIC needs to be based on the on-call personnel. Since a SMCI may happen anytime, the HIC needs to be identical for weekdays, weeknights, weekends and holidays. The mobility is critical, and the presence of the incident commander (IC), with a portable two-way radio, at the major areas of "action" is of great advantage. After visualizing the challenges, he/she may activate, through the portable communication system, any area of the hospital that is significant during the initial phase of a SMCI. Additional hospital administrators may be added to the HIC as the event progresses.

4 Other Sudden Mass Casualty Incidents

Decontamination for Chemical Exposure: at the Scene or at the Hospital

One of the major controversies on pre-hospital care for sudden chemical mass casualty incidents (SCMCIs) is whether to perform mass decontamination at the scene or at the hospital.

Common chemical agents that require decontamination after exposure:

- Organophosphates
- Mustards

Epidemiology:

The vast majority of the patients exposed to a chemical agent, such as an organophosphate, will be mildly contaminated ("walking wounded").

Lessons learned from the sarin gas attack in Tokyo subway:

- 82 % of patients that arrived at medical centers in the city self-evacuated or were transported by other citizens.
- 25 % of the hospital staff at local hospitals were contaminated.

M. Lynn, *Mass Casualty Incidents*,
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In a scenario of a SCMCI, where decontamination may be needed, there are two options:

1. Decontamination at the scene:
   Preferable because it decreases decontamination duration and decreases risk to hospital personnel when patients arrive at the hospitals.

   Nevertheless, the time to set up decontamination capability at the scene is too long and it is doubtful that the "walking wounded", which are the vast majority, will actually wait to be decontaminated. In addition, by the time decontamination is available, most critical patients, with respiratory failure, will probably expire. Therefore, critical patients should be transported rapidly to hospitals with mass decontamination capabilities by first responders dressed with personal protective equipment (PPE).

2. Decontamination at the hospital:
   If a hospital has a large pre-prepared decontamination area, it is preferable to decontaminate at the hospital, for the reasons below:

- Most patients will self-evacuate to hospitals.
- The decontamination area could be activated in minutes from notification.
- There are enough trained staff and personnel to handle the event.
- In addition to decontamination, patients will receive adequate medications and antidotes, which may be lacking at the scene.

Note: Decontamination at the hospital carries the risk of contamination of hospital personnel. Nevertheless, this risk should be minimized if the hospital staff is equipped with adequate personal protective equipment (PPE) and has performed enough training and drills.

Hospital Planning and Response to Sudden Chemical Mass Casualty Incidents

Assumptions:

- Sudden exposure of multiple people to a chemical agent may be classified as a sudden chemical mass casualty incident (SCMCI).

- The vast majority of the contaminated patients will be mildly contaminated ("walking wounded").
- The majority of contaminated patients will self-evacuate or will be transported by "buddies" to local hospitals.
- Although decontamination at the scene is desirable, it is time consuming in an unplanned, sudden event and therefore unrealistic.
- The "walking wounded" will probably self-evacuate to hospitals.
- Most critical patients, usually those with respiratory distress, will probably expire by the time scene decontamination is available. Therefore, critical contaminated patients should be transported rapidly to hospitals by first responders who must be equipped with personal protective equipment (PPE).
- There is a high probability that a large number of self-evacuated patients will flood the hospital campus.
- Hospitals should plan to prevent patient flooding, have a decontamination facility, and further manage patients from an SCMCI.

Prevention of patient flooding (page 38):

- Hospital security guards/police, regardless of their number, will most certainly be insufficient to prevent hundreds, if not thousands, of panicked self-evacuees from flooding the hospital campus.
- The most likely solution is to construct a **gated perimeter fence** around the hospital.

Decontamination:

1. Large urban medical centers in the community should plan for a large decontamination facility to handle a few hundred contaminated patients.
2. Criteria to construct a decontamination facility (Fig. 4.1):
   (a) Preferably in **open air**.
   (b) If in closed spaces (cities with severe winter), assure adequate ventilation.
   (c) Available **water source**.
   (d) Contaminated water should drain into the **city sewage system**, not into the rain collection system.
   (e) If no sewage system is available, an **underground container**, to collect contaminated water, should be a good alternative.

FIG. 4.1. Decontamination area at a hospital campus in Miami, FL

(f) Arrival and departure of ambulances to and from the decontamination facility should be **one way**. No U-turns!

(g) The decontamination facility should be divided into two separate areas, with a clear boundary separating them:

- Contaminated (*hot*)
- Clean

(h) Planning of the contaminated area:

- **Decontamination team (must wear protective gear):**
  - Team leader
  - Anesthesiologists/nurse anesthetists
  - Triage officer
  - Decontaminators
  - Emergency department (ED) physicians
  - Nurses
  - Respiratory therapists
  - Transporters (escorts)
  - Security guards

FIG. 4.2. "Fenced" stretcher

- **Intubation corner** for patients arriving in respiratory failure.
  - Standard intubation equipment and medications.
- **Chemical cart** – with standard medications and antidotes for common chemical agents.
- Distinct **showers for ambulatory and nonambulatory** patients should be available in the contaminated area.
- "**Fenced**" **stretchers** should be available, to allow the contaminated water to drain off the stretcher (Fig. 4.2).

(i) Planning for the clean area:

- **Personnel** (does not need to wear protective gear):
  - Team leader
  - Triage physician
  - ED physicians
  - Nurses
  - Respiratory therapists
  - Transporters (escorts)
- **Chemical cart** – with standard medications and antidotes for common chemical agents.
- **Clean stretchers and wheelchairs** should be available to which patients will be transferred after decontamination.

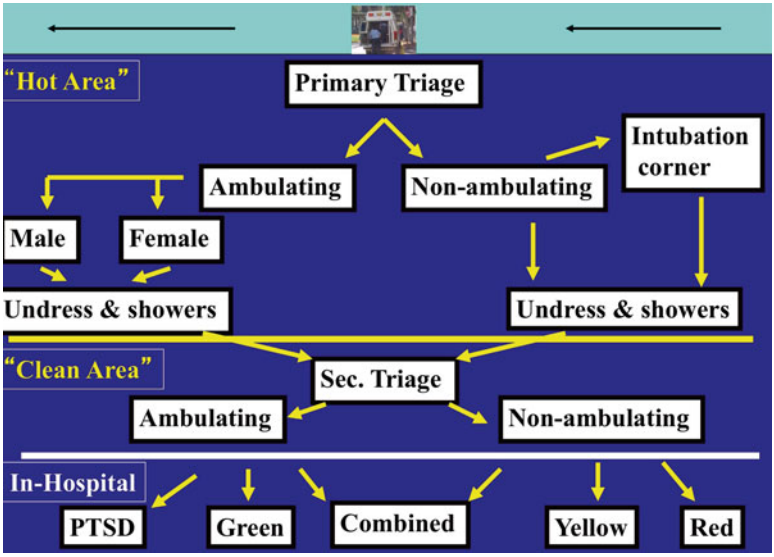

FIG. 4.3. Patient flow at the decontamination area

- **Colored charts**, by severity (critical, life-threatening, Red; Severe, non-life-threatening, Yellow; mild, Green), with temporary medical record numbers and matching wrist bands.

Flow of patients (Fig. 4.3):

- Arrival of contaminated patients at the entrance of the decontamination facility.
- Triage between ambulatory and nonambulatory.
- All patients are undressed and receive a prenumbered wristband, and their clothing is tagged with the same number, for future identification.
- Nonambulatory patients are triaged between normal and abnormal respirations.
- Patients with abnormal respirations are diverted to the intubation corner.

  Note: Patients with respiratory failure should be intubated prior to decontamination.

- Ambulatory and nonambulatory patients are decontaminated at their respective areas.

- After decontamination, patients may walk or be transported to the clean area.
- At the clean area, patients are triaged according to the severity of contamination.
- Comatose patients and infants are photographed to facilitate later identification.
- Patients receive the colored chart according to their severity and with the same number as the wristband.
- Patients receive medications and antidotes as medically indicated.
- Minimal documentation is performed at the clean site: only severity of the patient and medications received.
- Patients are transported to the respective in-hospital treatment area, according to severity.

In-hospital treatment areas:

- Red/Yellow (nonambulatory):
  - Patients who need ventilatory support and/or hemodynamically unstable
  - Physicians, one of which is a team leader
  - Nurses
  - Clerks
  - Transporters/escorts
  - Equipment:

    Ventilators
    Oxygen and suction
    Monitors
    Standard disposable ICU equipment
    Medications/antidotes
    Protocols based on symptoms

- Green (ambulatory)
  - All ambulatory patients
  - Physicians, one of which is a team leader
  - Nurses
  - Clerks
  - Transporters/escorts

    Oxygen, suction
    Monitors

Standard medical ED equipment
Medications/antidotes and protocols based on symptoms

Medical Principles for the Management of a "Dirty Bomb"

Definition

"Dirty bomb" is an explosive device (e.g., TNT) with the addition of a radioactive material.

It also named radiation dispersal device (RDD).

Medical Management

Since patients will suffer conventional injuries after an explosion, the presence of radioactive debris may not be diagnosed until the patient is assessed with a radiation spectrometer.

Therefore, the presence of radioactivity needs to be suspected after any explosion related to terrorism.

The medical priorities are the management of conventional injuries and should follow the principles of the Advanced Trauma Life Support (ATLS)®.

Decontamination of these patients may be performed before, during, or after the resuscitation and stabilization of conventional injuries.

Emergency Department Preparedness for "Dirty Bomb"

When planning the specific response for a "dirty bomb," in addition to the conventional planning, the emergency department (ED)/trauma center (TC – if applicable) should have large quantities of plastic rolls in storage.

When the notification is received of an explosion with the potential for radioactive debris, the ED/TC must activate the hospital plan for a conventional event and follow the pertinent checklist, as described in page 35.

In addition, the ED/TC should do the following:

- Cover the floor, stretchers, wheelchairs, beds, and carts with the plastic rolls.
- Assess the patient at the triage area, including the use of a radiation spectrometer.
- If patient is contaminated but otherwise stable from a trauma perspective, perform decontamination.
- If the patient is contaminated but in critical condition, stabilize the patient following ATLS® guidelines, including emergency surgery if needed. Perform decontamination once the patient is stable.
- When the event is over, discard the plastic covers, wash the ED/TC, and check for retained contamination.

Maritime Sudden Mass Casualty Incidents

On a cruise ship, there is an average of two physicians and three nurses on call for emergencies 24 h a day. Both the doctors and nurses are emergency medicine specialists.

There is an average of one ventilator, 3–4 cardiac monitors, 5–8 pulse oximeters, and one infirmary bed for 1000 passengers. Most of the ships don't have an operating room.

Each infirmary has the capability to provide critical care to one patient for 3–5 days.

It is possible that among the passengers, there will be a surgeon(s), an anesthesiologist(s), trauma/critical care nurse(s), or other specialized medical personnel.

If we use the definition that a sudden mass casualty incident (SMCI) is a "temporary state of insufficiency" (lack of enough personnel, equipment, supplies, evacuation) as described in Chap. 1,

every incident aboard a cruise ship (e.g., explosion) that exceeds 2–3 severely injured patients may be considered as a SMCI.

Assumptions:

The management of a SMCI on a passenger ship at sea assumes the following conditions:

- The cruise line/ship has a plan to respond to a SMCI.
- The plan should include the following:
  - The ship's *surge capacity* scheme for **s**taff, **s**pace, **s**upplies, and beds (**s**tretchers)

    Method to call for passengers who are medical professionals and are willing to help
    Preplanned alternate spaces on board the ship to provide medical care if the number of patients exceeds the infirmary capacity
    Scheme for deployment of extra equipment and supplies to preplanned alternate treatment areas
    Scheme for deployment of extra stretchers to alternate treatment areas

  - Evacuation considerations:

    Medical condition of the patient(s) and urgency for evacuation
    Existence of a heliport on board the ship
    Availability of rescue/medical helicopters in the area
    Distance to the closest port of call
    Medical capabilities at the closest port of call

  - Medical care

    Remember: The majority of patients in a SMCI aboard a ship will be walking wounded.
    Medical care should follow Advance Trauma Life Support (ATLS)® principles.
    Tourniquets may need to be used for limb hemorrhage. Caution needs to be used when applying improvised tourniquets, as they may worsen the bleeding!
    Priorities for evacuation need to be established after patients are treated and stabilized.

Deployment of Field Hospitals to Sudden Mass Casualty Incidents

National or international deployments of field hospitals to sudden mass casualty incidents (SMCIs) such as earthquakes may be necessary when the event occurs in remote areas, with scarce medical support or when the local medical facilities are overwhelmed, destroyed, or damaged.

In most instances, a field hospital will temporarily replace a local medical facility and provide emergency medical and surgical care to the population. Because the deployment of a field hospital may be hours after the incident occurred, it is unlikely to have to treat a large number of critical patients related to the SMCI.

The deployment of field hospitals need to be performed by organizations that are completely self-sufficient with respect to personnel, equipment, and air assets and that perform training and exercises on a consistent basis. Military field hospitals should be considered the gold standard.

This section will describe the most important issues to consider when planning deployment of a field hospital.

1. Information gathering

   - Immediately after a large-scale SMCI occurred, with the potential to deploy a field hospital, the *major news networks* should be used to collect preliminary information about the magnitude of the destruction and the potential for a field hospital deployment. Early estimations of the number of casualties are usually inaccurate.

2. Pioneer team

   - After the decision to deploy a field hospital is made by the government, a small pioneer team should be deployed to the area.
   - The composition of the pioneer team should be as follows:
     - Team commander
     - Medical advisor
     - Logistics advisor
     - Search and rescue advisor
     - Security officers

- The mission of the pioneer team:
  - Assess the area of the SMCI, preferably by air
  - Learn the magnitude of destruction of the medical facilities (if applicable) and the major medical needs
  - Evaluate the need for search and rescue teams
  - Notify the decision-makers regarding the findings
  - Recommend the final size and constitution of the field hospital
  - Decide the location of the field hospital (see below)
- After the final decision to deploy is made, the members of the pioneer team should decide where to place the field hospital. Criteria to choose the location:
  - Grounds next/close to the damaged medical facility, if possible.
  - The grounds should have good water drainage, to prevent flooding of tents in rainy seasons.
  - Do not use buildings because of safety considerations (thousands of aftershocks after a major earthquake).
  - The location of the field hospital could be easily secured (gated facilities, stadiums).
  - There should be enough space next to the field hospital to open a landing zone (LZ), for resupplies and evacuation of patients.
- The pioneer team should have satellite communications since cellular towers may be destroyed after a major earthquake.

3. Security
   - There is a need for robust security for every deployment of personnel to remote disaster areas, whether it is a national or international mission (Fig. 4.4).
4. Logistically self-sufficient
   - The field hospital needs to be logistically self-sufficient in the following areas, considering air transport limitations:
     - Electricity (generators).
     - Lodging (tents).
     - Water: Should not use or purchase local water (Fig. 4.5).
     - Safe food should be flown in with the logistics.

Fig. 4.4. Robust security at the entrance of an Israeli field hospital in Haiti, 2010

Fig. 4.5. Large quantities of water at an Israeli field hospital in Adapazari, Turkey, 1998

  - Showers and toilets.
  - Heavy lifting machinery such as forklifts.
  - Large automobile/ambulance (if applicable) for patient transport and locomotion of field hospital managers to city meetings and other missions.

5. Public health

   - Onset of a viral/bacterial gastrointestinal outbreak could be harmful for the personnel and impair significantly their mission.
   - It is imperative to institute strict discipline with respect to public health, following the rules below:

     - Hand wash.
     - Use of alcohol-based hand hygiene solutions.
     - Patients and personnel should have separate toilets.
     - Should not use local water for drinking or showering.
     - Only verified food should be ingested.
     - Daily toilet cleaning.

6. Interaction for local authorities

   - It is important to realize that the field hospital is a "visitor."
   - The mayor/commissioner/representative is the incident commander (IC) at the affected city/area.
   - It is the responsibility of the IC to decide the location of all field hospitals, in case there are more than one deployed.

7. Collaboration with other teams

   - In the aftermath of a major SMCI such as earthquakes, it is common to have many deployed field hospitals from all over the world.
   - Not all field hospitals have the same capacity and capability to provide specialized medical care.
   - It is important for the IC of the affected city/area to meet representatives from all field hospitals and perform screening of their medical specialties. It prevents duplications.
   - Citywide triage criteria and transport destinations should be set at this meeting, considering patient's condition and medical needs.

8. Complete hospital

- The population in the city/area for the earthquake may experience acute medical or surgical conditions.
- By default, patients will arrive at the local medical facility that has been damaged or destroyed.
- Patients should then be redirected to the field hospital deployed next to the local medical facility.
- Common medical/surgical conditions:
  - Surgical emergencies
  - Traumatic emergencies, related or not to the SMCI
  - Increased number of deliveries
  - Penetrating eye injuries
  - Acute coronary syndromes
  - Acute exacerbation of asthma
- Suggested medical specialties to be deployed in the aftermath of a SMCI, most commonly earthquakes:
  - General surgery/trauma/burns
  - Orthopedics
  - Obstetrics
  - Ophthalmology
  - General anesthesia
  - Neonatology/pediatrics
  - Medicine: Cardiology/pulmonary
  - Critical care
- It is important to have all specialties in place once the field hospital announces its opening. It prevents patients from walking from one field hospital to another to find appropriate medical care.

9. Adjacent landing zone

- When choosing its location, it is important to keep in mind the need to have an LZ in proximity to the field hospital.
- The LZ may later be used for flying in medical supplies and logistics (food, water) and evacuation of patients to hospitals outside the disaster area.

10. Central triage and evacuation for the affected city/area (Fig. 4.6)

- Critical patients should be evacuated by air (if applicable) to hospitals outside the affected city/area, where optimal medical care could be provided.

FIG. 4.6. Central triage and evacuation in the city of Duzce, Turkey, 1998

- Not all field hospitals in the affected city/area will have an adjacent LZ.
- It is therefore important for the IC of the disaster to designate one or more "central triage and evacuation" places where patients could be transported by ground, triaged according to severity, and air evacuated to hospitals outside the disaster zone.
- The "central triage and evacuation" should be in a secured area, large enough to include medical tents for triage and landing capability for helicopters. An open stadium should be an ideal location.

11. Media management

- Every deployment planning should include the protocols to handle the media. A few suggestions:
  - Plan a distinct area/tent in the "campus" of the field hospital for media deployment.
  - Appoint a spokesman. He/she will be the only contact of the media during the deployment period.
  - Schedule frequent media debriefings, at least twice daily.

5. Challenges Related to Mass Casualty Incidents

Challenges in the Management of Crush Injuries and Crush Syndrome

Definitions

Crush injury – Occurs as a result of *pressure* applied to any part of the body, usually extremities, for a prolonged period of time. It may be associated or not with limb fractures. Complications of a crush injury are *crush syndrome* and *compartment syndrome*.

Compartment syndrome – Occurs as a result of increased pressure inside the limb compartments, upper or lower, and may lead to loss of limb or life, if not diagnosed and treated early.

Crush syndrome – Is the systemic manifestations of the crush injury and includes:

- Metabolic abnormalities
  - Acidosis
  - Hyperkalemia
  - Hypocalcemia
- Renal failure

Challenges:
Management of trapped victims at the scene, prior to rescue.

M. Lynn, *Mass Casualty Incidents*,
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- Large amounts of fluids: 1–1.5 l/h during extrication.
- Consider administration of bicarbonate.
- Consider tourniquet application to limb prior to extraction.
- May need limb amputation to be able to extricate.
  - Requires the transport of a surgeon and anesthesiologist to the scene.

Management of patient immediately after extrication and at hospital:

- Large amounts of fluids until urinary output >300 cm^3/h.
- Correct acidosis, hyperkalemia, and hypocalcemia.
- Consider mannitol in addition to fluids in attempt to prevent renal failure.
- Renal failure may need dialysis.
- May require fasciotomy for limb compartment syndrome.

Challenges in the Management of Blast Injuries

This is not another chapter about blast injuries but rather a brief summary of the main challenges encountered when treating patients with this type of injuries.

To better understand the problems, I will briefly review the classifications of blast injuries:

- Primary – related to the impact of the blast wave (pressure wave) on the body.

  Damages usually occur in air-containing organs:
  - Tympanic membrane
  - Upper and lower airways
  - Lungs (Fig. 5.1)
  - Intestine

  It also may affect solid organs:
  - Heart (contusions, hemorrhages, air embolism, acute myocardial infarction, cor pulmonale) (Fig. 5.2)
  - Brain (contusion, contrecoup, hemorrhage, air embolism)
  - Extremities (blast amputations)

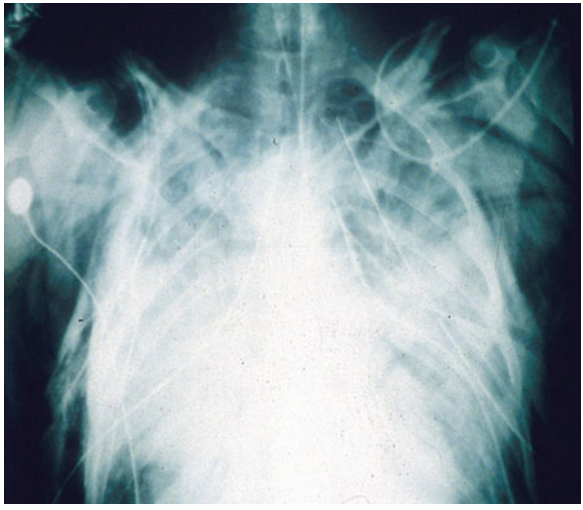

Fig. 5.1. Pulmonary blast injury

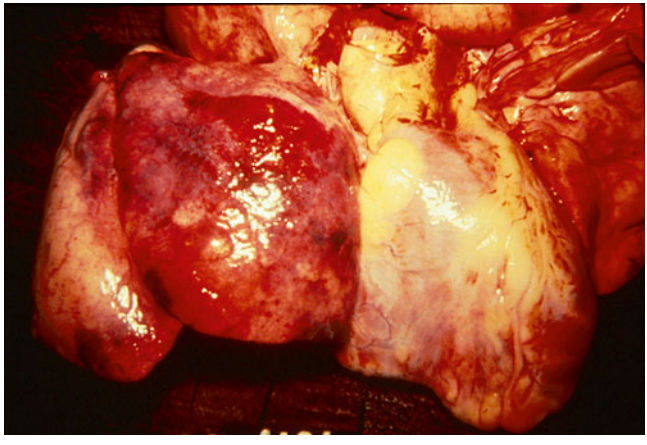

Fig. 5.2. Heart and lung contusions following blast

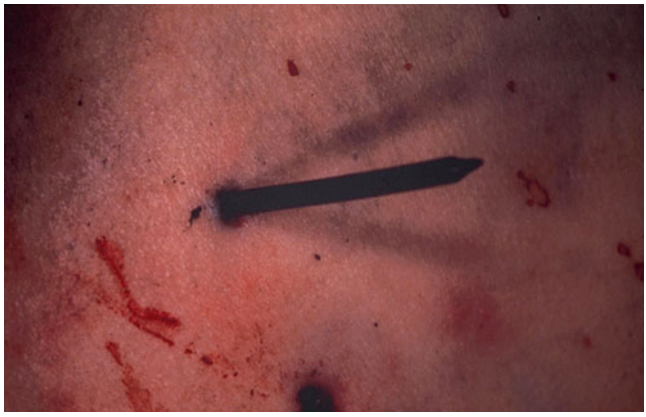

FIG. 5.3. Secondary blast injury: Nail penetrating extremity

- Secondary – Injuries caused by a shrapnel.
  - Usually penetrating injuries to torso and/or extremities (Fig. 5.3)
- Tertiary – Related to the "landing of the victim" after being pushed by the blast wave and blast wind.
  - Penetrating injuries if patients lands on sharp objects (Fig. 5.4)
  - Blunt trauma if patient lands on concrete or ground
- Quaternary – Injuries related to the heat of the explosion, known as "flash burns," usually affecting exposed areas such as the scalp, face, neck, and uncovered extremities.
- Multidimensional – Proposed recently by Israeli physicians to describe patients who present with all types of blast injuries simultaneously and the potential of viral exposure from infected body parts (bones) of the suicide bombers ("secondary shrapnel") (Fig. 5.5).

The following are the main challenges facing medical personnel when managing patients with blast injuries:

1. "Hidden" primary blast injuries in walking wounded patients:
   - Perform ear exam on all suspected patients. Injury to the tympanic membrane with otherwise normal physical exam justifies patient admission for observation (Fig. 5.6).

FIG. 5.4. Tertiary blast injury: patient "landed" on a piece of glass

FIG. 5.5. "Multidimensional" injury: Combination of all types of blast injuries simultaneously

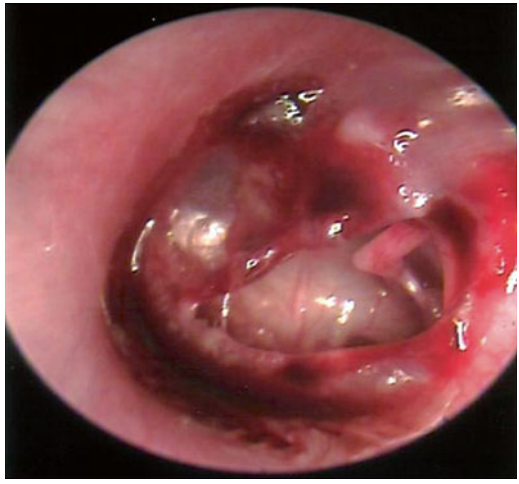

Fig. 5.6. Ruptured tympanic membrane following explosion

2. Management of severe pulmonary blast injury and prevention of air embolism:
   - Position of patients: Prone or left lateral and Trendelenburg.
   - Ventilatory support: Preferably noninvasive or low pressure, use high supplemental oxygen, and may consider nitric oxide.
   - Consider early extracorporeal membrane oxygenation (ECMO) for severe pulmonary hemorrhage.
   - Fluids: Maintain normovolemia.
   - Consider hyperbaric therapy for air embolism.
   - Early decompressive laparotomy for abdominal compartment syndrome.
3. Management of cardiac complications from primary blast injuries:
   - The standard care for acute myocardial infarction (AMI) due to air embolism to coronaries; consider hyperbaric therapy.
   - The standard management for pulmonary heart disease (cor pulmonale) from pulmonary embolism and severe acute respiratory distress syndrome.

4. Management of neurologic complications from primary blast injuries:
   - The standard care for brain injury caused by brain contusion, contrecoup, and hemorrhage.
   - Consider hyperbaric therapy for brain air embolism.
5. Management of "multidimensional" blast injury:
   - Priorities of care, for simultaneous blast injuries, follow ATLS® guidelines.
   - Immunoglobulin administration for "secondary shrapnel."

Challenges with Deceased and Body Parts Identification in Sudden Mass Casualty Incidents

Large-scale explosions and plane crashes are good models for sudden mass casualty incidents (SMCIs) and may cause a large number of deaths and dismembered or fragmented bodies.

The identification process of deceased and body parts in such situations is one of the greatest challenges of managing SMCIs (Fig. 5.7).

Below is the list of techniques and success rates in identifying corpses and body parts after explosions:

- Personal identification – 43 %
- Fingerprinting – 19 %
- Teeth examination – 13 %
- Personal documents – 10 %
- DNA testing – 10 %
- Specific signs – 5 %

In rare situations, repatriation of the deceased is necessary. It is important to remember that most countries prohibit air transport of bodies without previous embalmment.

FIG. 5.7. Challenges of body parts identification after explosions

Planning Exercises and Drills for Sudden Mass Casualty Incidents

Key components for planning exercises and drills for sudden mass casualty incidents (SMCIs):

- A **plan** for response to a SMCI needs to be written before the drill.
- Provide **lectures** to explain the plan to all individuals who may be involved in the response:
  - For prehospital: all first responders
  - For hospital: all medical, support personnel and administrators
- Organize **tabletop exercises**: Designed to bring together, into one room, all "players" that will respond to a SMCI (the police, fire department, EMS, hospitals, incident command, Regional Emergency Operations Center (REOC)). A large-scale incident is presented to them, and they have to resolve all challenges and pitfalls they present.

FIG. 5.8. Prehospital decontamination exercise. Courtesy of the US National Guard

- Conduct **sectorial** "**prehospital**" **exercises** (Fig. 5.8): Constructed to train portions of the prehospital response separately. Examples:
  - Scene deployment to a SMCI and triage of patients: could be performed at the ambulance station parking lot, using inflatable dummies or cards with description of injuries.
  - Interaction between various ambulances and incident control: could be performed at an empty stadium parking lot, using inflatable dummies, where a few ambulances are deployed simultaneously. All paramedics perform triage, and the scene commander decides on transport priorities.
- Conduct **sectorial** "**hospital**" **exercises**: Constructed to train portions of the hospital response separately. Examples:
  - Deployment of triage, patient arrival and photography.
  - Routes for emptying the emergency department.
  - Routes for influx of patients.
  - Deployment of alternate care sites.

FIG. 5.9. Full hospital exercise conducted yearly at a large medical center in Miami, FL

- Deploy a **full exercise**, preferably with prehospital and hospital training together (Fig. 5.9):
- There is no substitute for a well-organized, full-scale exercise testing all components of the response simultaneously.

Important issues to consider when organizing a SMCI drill:
Prehospital:

- First, there needs to be a detailed response plan for a SMCI.
- The drill needs to coincide with the written response plan.
- Try to make it a surprise.
- All agencies that are planned to be involved in a real SMCI should drill together:
  - Emergency medical services (EMS)
  - Fire department
  - Police
  - Regional Emergency Operations Center (REOC)
- Test everything and focus on the common problematic areas:
  - Opening access routes to the scene of the SMCI, together with the local police
  - Setup of decontamination capability, when exercising the response to a chemical exposure

  - Evacuation routes from the scene to local hospitals
  - Communications:

    Among all participating ambulance services
    Between ambulances, fire trucks, the police, and REOC with local hospitals

- Use other cities/counties that have planned to exercise in the near future to critique the drill.
- Modify the plan according to the lessons learned, and repeat the drill to correct deficiencies.
- Remember: A good, well-organized, and expensive drill is cheaper than a bad drill.

Hospital:

- First, there needs to be a detailed hospital response plan for a SMCI.
- The drill needs to coincide with the written response plan.
- Try to make it a surprise.
- All personnel planned to be involved in a real SMCI should drill together:
  - Hospital administrators
  - Abbreviated incident command
  - Medical and support personnel
- Test everything and focus on the common problematic areas:
  - Call-in of additional personnel
  - Activation of security
  - Setting up the triage area
  - Emptying the emergency department (ED)
  - Deployment of equipment to alternate treatment sites
  - Control and deployment of extra personnel to treatment sites
  - Arrival of ambulances at triage area:

    One-way route
    No U-turns

  - Transfer of patients from ambulance to hospital stretchers at the triage area, not in the ED
  - Identification of comatose and infant patients – photography
  - Registration of patients
  - Clinical management and control of patient destination

- Activation of operating rooms, intensive care units, blood bank, radiology, laboratory, and mental health
- Activation of family information center
- Activation of media center
- Incident command (IC)
- Communications:

  With EMS
  Between treatment sites
  With IC
  With REOC

- Use other hospitals that have planned to exercise in the near future to critique the drill.
- Modify the plan according to the lessons learned, and repeat the drill to correct deficiencies.
- Remember: A good, well-organized, and expensive drill is cheaper than a bad drill.

Telemedicine to Manage Sudden Mass Casualty Incidents Remotely

Telemedicine is gaining increasing popularity in recent years as a new approach to assist with patient care in remote locations, where expert physicians may not be available. Today, most medical personnel have cellular phones with cameras, capable to transmit still images and videos to experts all around the world. For these reasons, some advocate the use of telemedicine to manage disasters in remote locations.

Assumptions:

A few technological components need to be in place, both at the *sender and recipient* sites, for telemedicine to be practical:

- Cameras and screens
- Network system; cable, wireless, or satellite Internet

On pages 3 and 4 of this manual, I discussed the practical definitions and differences between the medical response for planned mass gatherings or progressive disasters and sudden mass casualty incidents (SMCIs).

There is little debate that telemedicine should be part of the response for a planned mass gathering such as a large sporting event or concert and for a progressive epidemic. In this situation, there is time for all technological components to be in place and to troubleshoot unexpected system failures, before the beginning of the event or during its slow progression. Even before large hurricanes, that may destroy telecommunications, there is enough time before it makes landfall to prepare a backup plan based on satellite communications.

Nevertheless, the use of telemedicine for SMCIs is questionable at best. Earthquakes, tsunamis with major flooding, tornados, and large-scale explosions may partially or completely destroy the communications infrastructure in the area, including at hospitals. Even when the foundation is intact, cellular signals and wireless Internet need to be available around the clock, at the scene, in the ambulances, and at the hospitals for telemedicine to be used without interruptions. This is usually not the case, and it's the reason why telemedicine should *not* be included in the standard response plan for SMCIs.

The only way for telemedicine to be practical in SMCIs is if all components of the response plan, such as the first responders, ambulances, and hospitals, have a backup plan based on satellite communications, which incurs prohibitive costs.

The Ten Commandments for Management of Sudden Mass Casualty Incidents

This section will discuss the ten most important issues to consider when planning the response to sudden mass casualty incidents (SMCIs). It will also serve as a quick summary of the manual.

First commandment: **One federal authority** for planning and response for disasters and SMCIs.

Numerous government and private agencies in the United States publish guidelines and benchmarks on how to manage disasters and SMCIs, most of which appeared after September 11, 2001. The recent Ebola outbreak demonstrated the disadvantage of multiple agencies publishing contradictory strategies on the same topic. For inexperienced emergency managers, this huge amount of information, sometimes conflicting, may cause confusion, as it is difficult for them to decide which guidelines to follow.

Optimally, only one single authority should be responsible for planning the response for disasters and SMCI and the only one to publish guidelines.

Second commandment: Perform **rapid evacuation** to hospitals (page 20).

Rapid scene evacuation and quick patient transport to hospitals has two advantages:

- Potential for improved survival for the critically injured patients
- Reduction of the "chaos phase" at the scene

Third commandment: Have a **specific hospital plan** to manage SMCI (page 25).

Although it is important to have a policy to handle all types of disasters and mass casualties, the "all-hazards approach," a hospital plan should be specific and detailed to the type of event.

One plan cannot possibly address the particularities of a progressive disaster, where the medical response occurs *before* the event reaches its full magnitude, and a SMCI, when the medical deployment is instant and happens *after* the event has already reached its full scale.

Fourth commandment: Estimate the **surge capacity** particular for your hospital (page 26).

Surge capacity is the estimation of the number of patients that a hospital can manage abruptly, above its normal capacity, and it is relative to its size. This number has important planning implications with respect to personnel, space, equipment, supplies, and ultimately costs.

Fifth commandment: **Prevent patients from flooding** the hospital (page 38).

Hundreds or even thousands of contaminated and/or panicked patients may attempt to enter the medical center after a chemical or toxicological event. The only realistic method to prevent patient flooding is to construct a gated fence surrounding the medical center.

Sixth commandment: Do a **quick identification and triage** of patients outside the emergency department (page 49).

An accurate and quick identification and triage outside the emergency department will impact patient disposition, speed of medical care provided, and possibly the outcome. It will also increase the chances of the families finding their loved ones.

Seventh commandment: Employ **MCI philosophy** for medical care of patients (page 50).

The medical care provided simultaneously to multiple injured patients differs from the care to a single patient and should follow SMCI philosophy.

Eighth commandment: Plan a **family information center** (page 52).

In the aftermath of an urban SMCI, it is expected that a large number of family members will be searching for their loved ones at area hospitals. It is critical that each hospital have a planned family information center where relatives could be accommodated, informed about the medical condition of the patient, and assisted with identification and tracking of missing loved ones.

Ninth commandment: Prepare to **decontaminate at the hospital** (page 58).

On-scene decontamination is relevant when a chemical incident occurs during a planned mass gathering, where a decontamination facility is already set up. During an abrupt and unplanned urban event (terrorism), on-scene decontamination, although preferable, is probably unrealistic.

Large urban medical centers should have the capability to perform mass decontamination within their facilities.

Tenth commandment: Conduct frequent **live drills** (page 80).

Lectures, conferences, and tabletop exercises are all important tools for teaching and learning topics on management of disasters.

But in reality, there is no replacement for well-conducted live drills to identify pitfalls and find better solutions to optimally respond to a SMCI.

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