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.

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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)

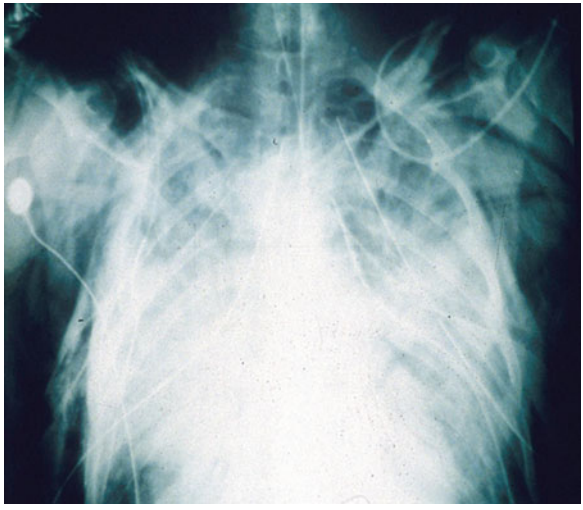

Fig. 5.1. Pulmonary blast injury

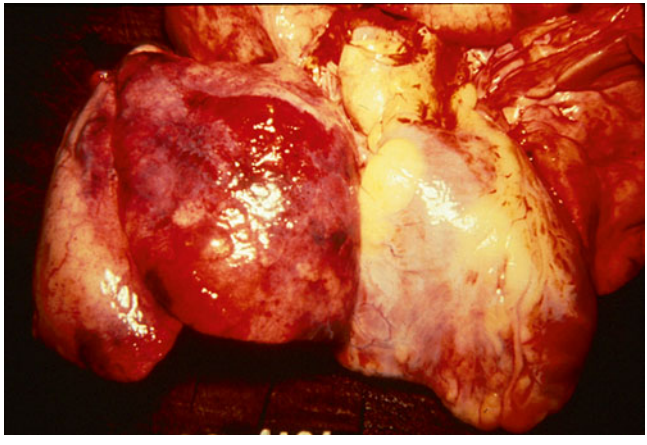

Fig. 5.2. Heart and lung contusions following blast

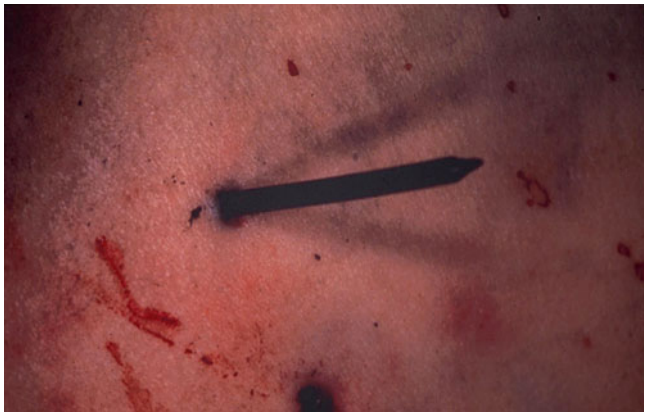

FIG. 5.3. Secondary blast injury: Nail penetrating extremity

- 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

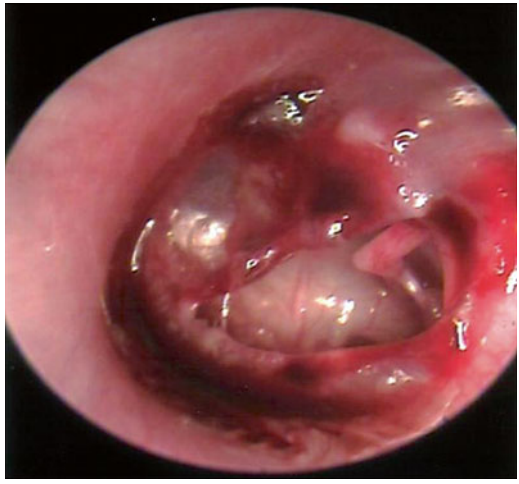

Fig. 5.6. Ruptured tympanic membrane following explosion

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.