Bombings: Injury Patterns and Care Pocket Guide

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UNIVERSAL BLAST

Blast Event

SCENE SAFETY

- Check in at staging area for safety briefing.
- Personnel safety
- PPE – Protective clothing, hard hats, eye protection, respiratory protection.
- Protection of uninvolved public and volunteers.
- Protection of injured.
- Be aware of secondary explosive devices.
- Be aware of multi-agent devices, e.g. chemical release, dirty bomb, etc.

TRIAGE CONSIDERATIONS

- Unique patterns, multiple and occult injuries.
- Death is often a result of combined blast, ballistic, and thermal effect injuries.
- Walking wounded and non-critical patients are time intensive.
- Hidden/internal injuries
- Overtriage can increase critical mortality – resulting from poor patient distribution from scene and self-referrals to hospitals.
- Up to 75% of victims self-refer to hospital.
- Do patients require decontamination?

Initial triage, trauma resuscitation, and transport should follow standard protocols for multiple injured patients or mass casualties.

FACTORS THAT CONTRIBUTE TO BLAST INJURY SEVERITY

ENVIRONMENT

- **Was The Bombing In An Open Or Closed Space?** *The effects of the blast wave are more intense in a confined space such as a building, bus or train.*

AGENT

- Low-order Explosive
- High-order Explosive

OTHER FACTORS

- Device type – large (vehicle) or small (suitcase)
- Delivery method
- Distance from device
- Protective barriers

Additional resources can be found at: www.acep.org/blastinjury or www.bt.cdc.gov/masscasualties/

PRIMARY INJURIES

Unique to high-order explosives; results from the impact of the over-pressurization wave with body surfaces by the blast wave.

HEAD INJURIES

- May or may not include history of loss of consciousness
- Headache, seizures, dizziness, memory problems
- Gait/balance problems, nausea/vomiting, difficulty concentrating.
- Visual disturbances, tinnitus, slurred speech.
- Disoriented, irritability, confusion.
- Extremity weakness or numbness.

TYMPANIC MEMBRANE – EAR INJURIES

- Evaluate and resuscitate per standing protocols.
- Impaired hearing may complicate triage process.
- Secondary evaluation and examination to identify all blast-related injuries including perforated tympanic membranes.
- Serious blast injuries can occur in the absence or presence of tympanic membrane rupture.
- Stable patients without signs and symptoms of significant blast injury, may be discharged after 4 to 6 hours of observation despite the presence of TM rupture.
- Patients should have urgent consultation and follow up care with ENT specialist.
- Spontaneous healing occurs in 50-80% of all patients with perforations.

ABDOMINAL INJURIES

- Treatment follows established protocols.
- Perforations can be delayed and develop 24 to 48 hours post blast. Manifestations of peritonitis can occur hours or days after a blast.
- There is the possibility of missed injury, especially in semiconscious or unconscious patients.

Treatment follows established protocols, but it is important to remember that these injuries may be easily missed.

BLAST LUNG – *Go to Blast Lung Injury Section*

SECONDARY, TERTIARY, AND QUATERNARY INJURIES ARE COMMON IN BLAST EVENTS, AND LARGE MAJORITY ARE NOT CRITICAL.

IT IS UNLIKELY TO EXPERIENCE PATIENTS WITH INJURIES ISOLATED TO ONE CATEGORY. A MORE LIKELY SCENARIO WOULD BE TO EXPERIENCE PATIENTS WITH A COMBINATION OF ALL THE INJURIES LISTED BELOW.

TREATMENT FOR MOST OF THESE BLAST INJURIES FOLLOWS ESTABLISHED PROTOCOLS FOR THAT SPECIFIC INJURY.

SECONDARY INJURIES

Results from flying debris and bomb fragments causing shrapnel wounds.

Common injuries include:

- Trauma to the head, neck, chest, abdomen, and extremities in the form of penetrating and blunt trauma.
- Fractures
- Soft tissue injuries

TERTIARY INJURIES

Results from individuals being thrown by the blast wind.

Common injuries include:

- Head injuries
- Skull fractures
- Bone fractures

QUATERNARY INJURIES

All explosion-related injuries, illnesses, or diseases not due to primary, secondary, or tertiary mechanisms.

Common injuries include:

- Burns
- Head injuries
- Exacerbation of pre-existing medical conditions

CRUSH INJURIES – *Go to Crush Injury Section*

COMBINED INJURIES

- Avoid tunnel vision on one injury.
- Monitor fluid replacement amounts when treating blast lung with another injury to avoid fluid overload which can exacerbate blast lung injury.
- Airway management and oxygenation/ ventilation are critical and performed with standard techniques.

BURN/BLAST INJURY

PREHOSPITAL

- Burn injury will require significant amounts of fluid resuscitation while avoiding fluid overload to prevent further pulmonary injury.
- Fluid resuscitation targeted to vital signs, to avoid hypotension; judicious fluid administration to maintain perfusion without volume overload.
- Transfer to a facility with specific expertise in both trauma and burn management, or at least the trauma management.

HOSPITAL

- Fluid resuscitation guided by urine output. Consider monitoring central venous pressure, and systemic vascular resistance when indicated.

CRUSH INJURY

Blast Event

ENTRAPPED PATIENT TREATMENT

- Fluid resuscitation before extrication
  - 1 L NS bolus, 1-1.5 L/hr infusion
- Limb Stabilization
- Minimize potential systemic effects of reperfusion (tourniquets)
- Consider alkalinization
  - 1 ampule Sodium Bicarbonate (50 mEq) prior to extrication, followed by 1 ampule of Sodium Bicarbonate with each liter of NS infused at 1-1.5 L/hr. Maintain a second IV w/o Sodium Bicarbonate.

Vital signs, oxygen, EKG, IV — *Additional treatment and transport*

IS CRUSH SYNDROME OR COMPARTMENT SYNDROME SUSPECTED?

Areas commonly affected:

- Lower/ Upper extremities
- Gluteal region
- Pelvis
- Abdominal muscles

SIGNS AND PRESENTATION OF CRUSH SYNDROME

The general condition of a patient with crush injury is dictated by: (**1**) other injuries, (**2**) delay in extrication, and (**3**) environmental conditions.

Common presentations are:

- Hypothermia or hyperthermia dehydration/shock
- Mental status varies from alert to comatose

Clinical concerns:

- The systemic effects are due to rhabdomyolysis and reperfusion of hypoxic and damaged tissues.
- Reperfusion of body part results in the systemic effects of crush injury.
- Patients may appear well until extricated, and then precipitously decompensate.
- Skeletal muscle damage is greatest after reperfusion.
- Cardiovascular instability due to massive fluid shift, electrolyte abnormalities, and direct myocardial toxicity.

SIGNS OF COMPARTMENT SYNDROME

Pain, Pallor, Paresthesia, Paralysis, Pulselessness Progression of symptoms (the 6th P)

Clinical concerns:

- Bone fractures with extravasation of blood or edema within a closed compartment.
- High velocity penetrating injury to muscles in closed compartment with extensive tissue disruption.
- Can also occur in sub acute fashion due to prolonged immobilization on hard surface.
- Compartment syndrome typically occurs in major muscle groups enclosed by inelastic, fibrous sheaths.
- Principal areas for compartment syndrome are upper extremities, including thenar and hypothenar eminences of hand, and lower extremities, including the foot.
- Untreated compartment syndrome will produce the same effects as a crush injury.

FIELD AMPUTATION INDICATED?

INDICATIONS

- Inability to safely extricate the patient.
- Continued environmental toxins that pose a hazard to victims or rescuers.
- When the extrication time would be long enough that it would endanger the patient's life without field amputation.

Field Amputation

- Best performed by an appropriately trained physician, such as a trauma or orthopedic surgeon.
- Ensure adequate analgesia and anesthesia.

CRUSH INJURY TREATMENT – PREHOSPITAL

CRUSH SYNDROME

- Primary survey and initial stabilization (ABCs)
- Fluid resuscitation before patient is extricated with severe or prolonged entrapment of limb or pelvis (more than a hand or foot).

COMPARTMENT SYNDROME

- Primary survey and initial stabilization (ABCs)
- Suspect compartment syndrome due to mechanisms of injury, examination, and patient complaints.
- Treat other injuries
- Immobilize affected part; do not use constricting bandages or MAST trousers.

CRUSH INJURY TREATMENT – HOSPITAL

CRUSH SYNDROME

- Fluid resuscitation
- Diagnose and treat other metabolic derangements:
  - Hyperkalemia
  - Hypocalcemia
- Brisk diuresis (2 ml/kg/hr)
- Pain control
- Anxiolysis

COMPARTMENT SYNDROME

- Primary survey, stabilization and resuscitation, secondary survey.
- Diagnosis through examination and confirmation with compartment pressure measurements.
- Treat systemic effects of compartment syndrome similar to crush injury.
- If injury is open:
  - Antibiotics, tetanus, jet irrigation.
  - Debridement of nonviable tissues.
  - Early amputation for severely injured limbs may be required to reduce sepsis.
- Fasciotomy

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BLAST LUNG INJURY

Blast Event

INITIAL TRIAGE, TRAUMA RESUSCITATION, AND TRANSPORT SHOULD FOLLOW STANDARD PROTOCOLS FOR MULTIPLE INJURED PATIENTS OR MASS CASUALTIES

Was the Bombing in an Open or Closed Space?

There is a higher incidence of blast lung injury in enclosed spaces

NO

SIGNS OR SYMPTOMS SUGGESTIVE OF BLI OR RESPIRATORY DISTRESS

SIGNS – Apnea, tachypnea or hypopnea, hypoxia and cyanosis, cough, wheezing, dullness to percussion, decreased breath sounds, or hemoptysis

SYMPTOMS – Dyspnea, hemoptysis, cough, and chest pain

CLINICAL CONCERNS – Blast lung, hemothorax, pneumothorax, pulmonary contusion and hemorrhage, A-V fistulas (source of air embolism), penetrating chest trauma, and blunt chest trauma. Evaluate patient for >10% BSA burns, skull fractures, and penetrating torso or head injuries

NO — **COMPROMISED VENTILATION** — **YES**

Vital Signs, Oxygen, Monitor IV

Airway Management Protocol

If ventilatory failure occurs or is imminent, patients should be intubated; caution should be used as positive pressure and mechanical ventilation may increase the risk of further pulmonary injury

Appropriate Treatment and Transport

MANAGEMENT

OXYGENATION

- High flow O_2 sufficient to prevent hypoxemia via non-rebreather mask, CPAP, or endotracheal intubation.
- Hemothorax or Pneumothorax

CLOSE OBSERVATION

- Chest decompression for clinical presentation of tension pneumothorax.
- Fluid administration
- Provide enough fluid to ensure tissue perfusion but avoiding volume overload.

AIR EMBOLISM*

- Position in prone, semi-left lateral, or left lateral positions; transport to a facility with a hyperbaric chamber.

**Close observation for any patient suspected of BLI for the development of tension pneumothorax transported by air.*

HOSPITAL DIAGNOSTIC EVALUATION

- Chest radiography
- Arterial blood gases, computed tomography, and doppler ultrasound can be used to help diagnose BLI and air emboli.
- Most lab and diagnostic testing conducted per resuscitation protocols – based upon nature of explosion (e.g. confined space, fire, etc.).

HOSPITAL DISPOSITION AND OUTCOME

- No definitive guidelines for observation, admission, or discharge following emergency department evaluation for patients with possible BLI following an explosion.
- Patients diagnosed with BLI may require complex management and should be admitted to an intensive care unit. Patients with any complaints or findings suspicious for BLI should be observed in the hospital.
- Discharge decisions will also depend on associated injuries; other issues related to the event, including the patient's current social situation.
- In general, patients with normal chest radiographs, blood gasses, and pulse oximetry who have no complaints suggesting a BLI, can be considered for discharge after 4-6 hours of observation.
- Data on the short and long-term outcomes of patients with BLI is currently limited. However, in one study conducted on survivors one year post injury, no patients had pulmonary complaints, all had normal physical examinations and chest radiographs, and most had normal pulmonary function tests.

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