Blast Injury: Assessment and Management

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There are no conflicts to disclose.
Objectives

• **Terminal Learning Objective:** Understand the assessment and management of the various types of injuries occurring from explosive blasts

Enabling Objectives:

• Understand the physics involved in explosive events
• Understand the different types of explosives and how they affect injury
• Recognize the immediate and delayed medical injuries that can result from explosive events and their management
Background

• Explosion: “An event that occurs when a substance rapidly releases energy and produces a large volume of gaseous products.”

• Blasts produce:
  • Blast wave: compression of gases
  • Blast wind
  • By-products: gas, particles, debris
Why do we care?

• This happens outside of combat related events
• Civilian based terrorism:
  • Madrid (2004)
  • London (2005)
• Non terrorist in our own backyards

Dave Chidley/Associated Press - available
How to approach a blast injury?

• Ask the right questions!
1) What “Blew Up”?

• And - How much?

• Explosives classified into 2 categories:
  • High Order
  • Low Order
High Order Explosives

- High Reaction rate
- Supersonic over-pressurization shock wave
- 3 parts:
  - blast front
  - decay
  - negative pressure
HO Explosives

- Nitroglycerine
- TNT (Dynamite)
- Ammonium nitrate - fuel oil combination
- C4
- TATP
Low Order Explosives

- Propellants - burn slowly
- Enclosed - increases the rate but still lack the ability to produce over-pressure wave
- Injuries:
  - blast wind
  - projectiles
  - thermal
LO Explosives

- Gasoline - molotov cocktails
- Black Powder - pipe bombs
2) Where did it “blow up”?

- Enclosed space, partially enclosed, open
- Confined/Enclosed - reflection of blast wave
  - Multiple contacts
  - Amplification of blast wave (2-9X)
  - Increase mortality
3) Where was the patient?

- Different injury patterns as distance from blast increases
- Intervening structures

CDC/ACEP. Bombings: Injury Patterns and Care
## Table 5. Bomb “Stand-Off” Distances.

<table>
<thead>
<tr>
<th>Container or Vehicle Description</th>
<th>Maximum Explosives Capacity</th>
<th>Lethal Air Blast Range</th>
<th>Minimum Evacuation Distance</th>
<th>Falling Glass Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe 2” x 12”</td>
<td>5-6 pounds</td>
<td></td>
<td>850 feet</td>
<td>259 meters</td>
</tr>
<tr>
<td>Pipe 4” x 12”</td>
<td>20 pounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe 8” x 24”</td>
<td>*20 pounds (uncommon)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle 2 liter</td>
<td>5 pounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle 2 gallon</td>
<td>10 pounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle 5 gallon</td>
<td>70 pounds (uncommon)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boxes Shoe box</td>
<td>30 pounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Briefcase</td>
<td>50 pounds</td>
<td></td>
<td></td>
<td>*855 feet</td>
</tr>
<tr>
<td>1 cubic foot box</td>
<td>*50 pounds (uncommon)</td>
<td></td>
<td></td>
<td>1250 feet</td>
</tr>
<tr>
<td>Suitcase</td>
<td>225 pounds (uncommon)</td>
<td></td>
<td></td>
<td>*855 feet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1250 feet</td>
</tr>
</tbody>
</table>
## Safe Distance

<table>
<thead>
<tr>
<th>Vehicles</th>
<th>Weight</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact sedan</td>
<td>5000 pounds (227 kilos) in trunk</td>
<td>100 feet 30 meters 1500 feet 250 feet</td>
</tr>
<tr>
<td>Full size sedan</td>
<td>1050 pounds in trunk</td>
<td>125 feet 38 meters 1750 feet 387 meters</td>
</tr>
<tr>
<td>Passenger van or cargo van</td>
<td>4000 pounds</td>
<td>200 feet 61 meters 2750 feet 838 meters</td>
</tr>
<tr>
<td>Small box van</td>
<td>10000 pounds</td>
<td>300 feet 91 meters 3750 feet 1143 meters</td>
</tr>
<tr>
<td>Box van or water/fuel truck</td>
<td>30000 pounds</td>
<td>450 feet 137 meters 6500 feet 1982 meters</td>
</tr>
<tr>
<td>Semi-trailer</td>
<td>60000 pounds</td>
<td>500 feet 183 meters 7000 feet 2134 meters</td>
</tr>
</tbody>
</table>
4) What types of Injuries do they have?

- Mechanisms
  - Primary
  - Secondary
  - Tertiary
  - Quaternary
Primary - Blast Wave

- Blast wave transfers energy to any objects within its path
- Seen only with HO explosives
- Severity:
  - Peak initial pressure wave
  - Duration of overpressure
  - Medium
  - Distance from incident blast wave
  - Nature and number of reflections
Mechanism

- Irreversible Work Effect
  - related to the differences in tissue tensile strength and the speed of the blast wave through different tissues
  - tissue is compressed by the blast wave and then re-expand
  - Damage occurs with compression
Primary - Systems

- Most commonly effected:
  - Ears
  - Respiratory
  - GI

<table>
<thead>
<tr>
<th>Overpressure (psi)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Frame house destroyed</td>
</tr>
<tr>
<td>3-5</td>
<td>Typical commercial construction destroyed</td>
</tr>
<tr>
<td>5</td>
<td>Lympamic membrane rupture (threshold)</td>
</tr>
<tr>
<td>.5</td>
<td>Lympamic membrane rupture in 50% of patients</td>
</tr>
<tr>
<td>30-40</td>
<td>Possible lung injury (threshold)</td>
</tr>
<tr>
<td>40</td>
<td>Reinforced concrete construction destroyed</td>
</tr>
<tr>
<td>75</td>
<td>Lung injury in 50% of patients</td>
</tr>
<tr>
<td>100</td>
<td>Possible fatal injuries</td>
</tr>
<tr>
<td>200</td>
<td>Death most likely</td>
</tr>
</tbody>
</table>
Ears

- TM perforation
- Ossicle dislocation
- Hearing disruption
Ears as Triage

• No longer felt to be a reliable triage tool
• Israeli experience:
  • Isolated pulmonary and GI barotrauma
  • 74% isolated TM perfs
• Madrid experience:
  • 24% with critical injuries had intact TMs
Lungs

- Pulmonary barotrauma (Blast Lung) is the most common cause of death in initial survivors from primary blast injury.
Blast Lung

- Pulmonary Contusions
  - micro hemorrhage
- Wheezing, dyspnea, SOB +/- hemoptysis

- Management
  - Same as other pulmonary contusion
  - O2, resp support, judicious fluid use
Other Pulmonary Injuries

- Barotrauma
  - pneumothorax
  - pneumomediastinum
  - S/C air
Acute Gas Embolism

- Air Embolism
  - distal ischemia:
    - limbs/GI/CVS/Neuro (brain/spinal cord)
- Symptoms:
  - arrhythmias, seizures, altered mental status, neurological deficits
- Worsened / Often post PPV
- Tx: HBO, high flow O2, LLD positioning
GI Injury

- Primary injuries
- Perforations
- hemorrhage
- mesenteric injuries
- solid organ contusions/lacerations
- testicular rupture

- Presentation
  - Pain, N/V, GIB, Tenesmus
  - Inconsistent
  - Variable
  - Children higher risk
Head

- PBI - concussion & intracranial injuries without external signs of injury
- Also from secondary and tertiary injuries
Secondary Injuries

- Result of bomb fragments and debris being propelled by the blast.
- Intentional blast often have “added” items - nails, bolts etc
- More common than PBI
- Most common cause of death in blast victims
Secondary

- Range of injuries
  - soft tissue injuries
  - penetrating
  - fractures
  - traumatic amputation
  - Mainly exposed areas
  - Can affect thoracic and intra-abdominal

- 50% are glass associated
- Hard to distinguish abrasions from penetrating injuries
- High index of suspicion
Secondary

- Eyes
- 10% blast survivors
- Often glass related
- Globe perforations, hyphema, retinal detachments, lid lacerations, FB and corneal abrasions.
- Can be initially overlooked
Tertiary Blast Injuries

- Patients' body is propelled into another object
- Secondary to blast wind
- Generate forces in excess of 15G’s
- Usually in patients close to explosion
Tertiary Injuries

- Closed/Open HI
- Fractures/Dislocations/Amputations
- Contusions/Abrasions
- Impalements
Quaternary Injuries

- Burns
- Poisoning (CO,CN)
- Chemical, Biologic, Radiologic vector
- Exacerbation of underlying disease
- Crush injuries from structural collapse
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Blast Injury - General Management

- Generally - combination of all types of injury
- As with all trauma - avoid focusing on single injury
- Initial work up - b/w, plain XR, FAST and CT
- Initial treatment can be contradictory
5) How Many are injured

- How many injured and severity
- What are your local resources
- Lessons learned
Lessons Learned

• Radiology
  • Key management bottleneck
  • Multiple patients - multiple imaging modalities and images
  • Start with CXR/Pelvis/C-Spine and based on suspected penetrating injuries
  • Scout CT - head to toe before dedicated imaging
Lessons Learned

- Other bottlenecks
- Surgical Services
- ICU/Critical Care
- Pharmacy
Other Considerations

- Post exposure Prophylaxis
  - Victims with penetrating injury should have Hep B
  Post Exposure Prophylaxis.
- HIV only if known reason for high risk exposure
- Tetanus
Other Considerations

- Psychological
  - Family Integration and Support Center (FISC)
- Psychological First Aid Providers
  - Victims, Families, Responders
- Appropriate Follow-up
Responders Psychological

- Coordinators aware of stress vulnerabilities
- Work in buddy system
- Enforced breaks
- Psychological first aid / debriefing
Summary

- Trauma from an explosion depends on:
  - size and nature of the explosive
  - container
  - environment of the explosion
    - barriers, debris, objects
  - distance from the blast center
Questions

1. How much and what?
2. Where did it happen?
3. Where was the patient?
4. What injuries do they have?
5. How many are injured?
Questions
References


