Clinical Manifestation of Blast Injuries
ADVANCED EXPLOSIONS & BLAST INJURIES

Outline

- Types of injuries seen
- Injury characterization
- Specific Injuries
  - Primary
  - Secondary
  - Tertiary
  - Quaternary
  - Quinary

Madrid Bombing - Injuries

- Rupture of the tympanic membranes occurred in 99 of 243 victims
- Chest injuries in 97/243 victims
- Shrapnel wounds in 89/243
- Fracture in 44
- Burns in 45
- Eye injuries in 41
- Abdominal injuries in 12
- Traumatic amputations in 5
Boston Marathon Bombing - April 15, 2013

- 3 deaths prior to reaching the hospital
- 264 injuries
- More than 20 with critical injuries
- Amputations, soft tissue injuries
- TM rupture

Trauma Activations at Mass General Hospital

<table>
<thead>
<tr>
<th>Tertiary Blast Injury</th>
<th>Injuries due to impact with another object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Blast Injury</td>
<td>Injuries due to missiles being propelled by blast force</td>
</tr>
<tr>
<td>Primary Blast Injury</td>
<td>Injuries due to the blast wave itself</td>
</tr>
</tbody>
</table>
Primary Blast Injuries

- Affect air-filled organs or air-fluid interfaces
- Rupture of tympanic membranes, pulmonary injury, air embolization and rupture of hollow viscera are the most common patterns

Tympanic Membrane Rupture

- Occurs at the lowest pressure (5 psi)
- May be bilateral
- May be the earliest sign to look for
  - Deafness, tinnitus and vertigo
- If more severe, may cause dislocation of the oval, round window or the ossicles
  - Permanent hearing loss
- Other organs need higher pressures (56-76 psi) so if the TM is intact, they are unlikely
The drawing of a traumatic perforation shows an irregular margin or rim with blood or a blood clot, and the drawing of a permanent central perforation shows a tympanocele.

**Pulmonary Injuries**

- Second most common primary blast injury
- Hemorrhage
  - Pulmonary contusion (appearing as a bihilar "butterfly" pattern on chest radiographs)
  - Pneumothorax
  - Hemothorax
  - Pneumomediastinum
  - Subcutaneous emphysema
Pulmonary Injuries

- Onset of symptoms is commonly within minutes
  
  - Controversial

Body Armor

- Protects from secondary blast injuries
- Does not protect from primary blast injury
TM Perforation - Pulmonary Injury

- Among 17 critically ill victims with pulmonary injuries from the blast:
  - 13 had ruptured tympanic membranes and 4 did not
- Rupture of tympanic membranes occurred in 18 of 27 critically injured victims
  - 17 of these were bilateral

Data from Madrid

Screening

- 647 survivors of explosions on buses used immediate radiography of the chest to screen for pulmonary injuries from the blasts
- Primary injuries, in some form, were found in 193 persons:
  - 142 had isolated perforation of the eardrum

Data from Israel
Screening

- 51 had other forms of primary blast injuries:
  - 18 with isolated pulmonary injuries
  - 31 with combined otic and pulmonary injuries
  - Two with intestinal injuries

Visceral Injury

- Visceral injury is third most common primary blast injury
- Rupture of the colon and, less frequently, the small intestine may occur as an immediate result of a blast
- Mesenteric ischemia or infarct can cause delayed rupture of the large or the small intestine; these injuries are difficult to detect initially
Visceral Injuries

- The ileocecal area is the most vulnerable
  - Accumulates gas
- Observed findings
  - Hemorrhages
  - Edema
  - Perforations
  - Lacerations

Other Injuries

- Serous retinitis
- Concussion
- Air embolism may be seen and can present as stroke.
  - MI, acute abdomen.
  - Blindness, deafness, spinal cord injury, or claudication
Ruptured Globes

Secondary Injuries

- Penetrating injuries from:
  - Primary fragments (fragments that are part of the weapon)
  - Secondary fragments (those that result from the explosion)
Tertiary Injuries
- Caused by trauma from falling objects or from bodies being thrown against other objects
  - Blunt and penetrating injuries
  - Crush syndrome and secondary rhabdomyolysis
  - Open or closed head injuries

Crush Syndrome
- Rhabdomyolysis:
- Myoglobinuric renal failure
- Hyperkalemia

Pelvic Fractures
Crush Syndrome-Earthquakes

### Table 1. Statistics Related to Major Earthquakes in the Past 20 Years

<table>
<thead>
<tr>
<th>Location and Year</th>
<th>Crush Syndrome</th>
<th>Death</th>
<th>Rhabdomyolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kobe, Japan, 1995</td>
<td>32,000</td>
<td>680</td>
<td>2,264</td>
</tr>
<tr>
<td>Kocaeli, Turkey, 1999</td>
<td>9,000</td>
<td>2,300</td>
<td>255</td>
</tr>
<tr>
<td>Miranda region, Ecuador, 1985</td>
<td>6,000</td>
<td>380</td>
<td>0</td>
</tr>
<tr>
<td>Christchurch, New Zealand, 2011</td>
<td>2,000</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>Christchurch, New Zealand, 2015</td>
<td>2,000</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>Sichuan, China, 2008</td>
<td>6,000</td>
<td>1,225</td>
<td>157</td>
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<td>6,000</td>
<td>1,225</td>
<td>157</td>
</tr>
<tr>
<td>Sumatra, Indonesia, 2004</td>
<td>2,000</td>
<td>324</td>
<td>36</td>
</tr>
<tr>
<td>Haiti, 2010</td>
<td>2,000</td>
<td>324</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
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<td>680</td>
<td>2,264</td>
</tr>
</tbody>
</table>

Rhabdomyolysis

- Secondary complication of crush syndrome
- Myoglobinurea and CK elevation

Quaternary Injuries

- Burns (chemical or thermal)
- Toxic inhalation of carbon monoxide or hydrogen cyanide gas
- Exposure to radiation: ARS and Internal Contamination
- Inhalation of dust containing coal or asbestos
- Exacerbation of chronic illnesses
Exacerbation of Chronic Illnesses

- Asthma and COPD
- Diabetes Mellitus
- Hypertension
- Coronary artery disease
- Peptic ulcer disease
- Alcohol and substance abuse
- Mental health

Quinary Blast Injuries

- SIRS manifestations
  - Fever
  - Tachycardia
  - Hypotension
- No infectious source recognized
- BAL reveals eosinophilia
- Management supportive +/- steroids

Any Questions or Comments?