Blast Injuries
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GA Poison Center / Emory University / Centers for Disease Control and Prevention
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Most CBRNE start with a blast

- “If you know how to handling bombing victims, you can handle 70% of all disasters.”

Col Isaac Ashkenazi
HISTORICAL INCIDENTS
Discovery

• Believed to be discovered in China in the 10th century
• Called black powder or gun powder
  – Charcoal
  – Potassium nitrate
  – Sulfur
• Used for signals and fireworks
• Then used in warfare

A Mongol bomb thrown against a charging Japanese samurai during the Mongol Invasions of Japan, 1281
Dynamite

• Invented by Alfred Nobel
• Added silica to liquid nitroglycerine making the more malleable dynamite
• Also invented blasting caps that were made with a fuse and gunpowder
Texas City Disaster 1947

- 7 KiloT of ANFO exploded on board of SS Grandcamp in the port killing 581 people
Composition C4

- Greater than 90% RDX
- Needs a blasting cap to detonate
- 1.34 as strong as TNT

Inserting Blasting caps into C4
1993 – WTC Bombing

The underground parking garage of the World Trade Center one day after the February 1993 explosion.
Ammonium Nitrate/Fuel Oil (ANFO)

- 80% of explosive used in the USA
- High explosive
  - Requires a booster
1995 - Oklahoma City Bombing

- Ryder truck detonated in front of building at 9:02am (CST)
- Blast destroyed 1/3 of the building, creating a crater that was 30 ft wide and 8 ft deep
- Blast destroyed or damaged 324 buildings within radius of sixteen blocks, burned 86 cars, and shattered glass in 258 nearby buildings
- 168 confirmed dead
• By the end of the day, 153 victims had been treated at St. Anthony Hospital, eight blocks from the blast, over 70 at Presbyterian, 41 at University, and 18 at Children's.
Birmingham Women Health Center 1998

• Eric Robert Rudolph
  – 1996 Olympic Centennial Park
  – Otherside (Gay) nightclub
  – Women’s health centers
  – FBI top ten list
World Trade Center
September 11th, 2001

- Both 110-floor Twin Towers of the World Trade Center were destroyed along with 5 others establishments (including 2 subway stations)
- 25 surrounding buildings were damaged
- 2749 people were killed in WTC and on board both American flight 11 and United flight 175
Who are the threats?


http://www.rms.com/Publications/9_11_Retrospective.pdf
Motives as Reported in ATF Database

**Table 5** Number of deaths by etiology for explosive, incendiary, and premature bombing events from January 1, 1983, to December 31, 2002

<table>
<thead>
<tr>
<th>Etiology of Bombing Event Deaths</th>
<th>Explosive (%)</th>
<th>Incendiary (%)</th>
<th>Premature (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determined</td>
<td>363 (94.0)</td>
<td>129 (92.8)</td>
<td>75 (43.1)</td>
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<tr>
<td>Homicide</td>
<td>268 (69.4)</td>
<td>69 (49.6)</td>
<td>10 (5.7)</td>
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<tr>
<td>Suicide</td>
<td>53 (13.7)</td>
<td>3 (2.2)</td>
<td>1 (0.6)</td>
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<tr>
<td>Vandalism</td>
<td>10 (2.6)</td>
<td>3 (2.2)</td>
<td>54 (31.0)</td>
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<tr>
<td>Revenge</td>
<td>14 (3.6)</td>
<td>40 (28.8)</td>
<td>5 (2.9)</td>
</tr>
<tr>
<td>Protest</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Labor-related</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Extortion</td>
<td>1 (0.3)</td>
<td>1 (0.7)</td>
<td>1 (0.6)</td>
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<tr>
<td>Excitement</td>
<td>1 (0.3)</td>
<td>0 (0.0)</td>
<td>3 (1.7)</td>
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<tr>
<td>Domestic violence</td>
<td>13 (3.4)</td>
<td>3 (2.2)</td>
<td>0 (0.0)</td>
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<tr>
<td>Insurance fraud</td>
<td>3 (0.8)</td>
<td>3 (2.2)</td>
<td>1 (0.6)</td>
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<tr>
<td>Intimidation</td>
<td>0 (0.0)</td>
<td>7 (5.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Undetermined</td>
<td>23 (6.0)</td>
<td>10 (7.2)</td>
<td>99 (56.9)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>386 (100.0)</strong></td>
<td><strong>139 (100.0)</strong></td>
<td><strong>174 (100.0)</strong></td>
</tr>
<tr>
<td>Type of Material</td>
<td>Injuries (%)</td>
<td>Deaths (%)</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Determined</td>
<td>4,050 (68.3)</td>
<td>595 (85.1)</td>
<td></td>
</tr>
<tr>
<td>Nitrate-based fertilizers</td>
<td>1,586 (26.7)</td>
<td>181 (25.9)</td>
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<tr>
<td>Smokeless powder</td>
<td>818 (13.8)</td>
<td>114 (16.3)</td>
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<tr>
<td>Inflammable liquids</td>
<td>579 (9.8)</td>
<td>139 (19.9)</td>
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<tr>
<td>Black powder</td>
<td>526 (8.9)</td>
<td>47 (6.7)</td>
<td></td>
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<tr>
<td>Pyrotechnics</td>
<td>232 (3.9)</td>
<td>18 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Dynamite</td>
<td>161 (2.7)</td>
<td>90 (12.9)</td>
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<tr>
<td>Match heads</td>
<td>139 (2.3)</td>
<td>2 (0.3)</td>
<td></td>
</tr>
<tr>
<td>C-4</td>
<td>5 (0.1)</td>
<td>1 (0.1)</td>
<td></td>
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<tr>
<td>Trinitrotoluene</td>
<td>4 (0.1)</td>
<td>3 (0.4)</td>
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<tr>
<td>Undetermined</td>
<td>1,881 (31.7)</td>
<td>104 (14.9)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,931 (100.0)</td>
<td>699 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>
### INCIDENTS BY STATE

#### South

<table>
<thead>
<tr>
<th>State</th>
<th>Explosives</th>
<th>Incendiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Arkansas</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Delaware</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>District of Columbia</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Florida</td>
<td>135</td>
<td>26</td>
</tr>
<tr>
<td>Georgia</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Kentucky</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Louisiana</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Maryland</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>Mississippi</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State</th>
<th>Explosives</th>
<th>Incendiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Carolina</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>South Carolina</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Tennessee</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Texas</td>
<td>61</td>
<td>25</td>
</tr>
<tr>
<td>Virginia</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>West Virginia</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Virgin Islands</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**TOTALS**: 359, 95, 119, 49
Special Characteristics of Bombing Victims

• Victims of terrorist bombings (n = 906) were compared with 55,033 casualties of non-terror related trauma.

• Bombing resulted in significantly different:
  – Injury complexity
  – Increased severity
  – More body regions involved
  – Enhanced use of intensive care
  – Prolonged hospital stay
  – More surgical interventions
  – Increased hospital mortality
Prehospital

- Incident command
- Securing the area
- Secondary device survey
- Triage categorization
- Regular trauma protocols
- Radiation survey
- Survey for chemical contamination
- Did the blast occur in an enclosed setting?
Secondary Devices

• Secondary explosive devices are designed to explode after a primary explosion has attracted large numbers of responders to the scene to inflict additional injury, damage, and fear.

• Hidden in out of view locations, or camouflaged
U.S. Fire Administration Guidelines

• Anticipate the presence of a secondary device at any suspicious incident.
• Search for a secondary device before moving into the incident area.
• Avoid touching or moving anything that may conceal an explosive device.
U.S. Fire Administration Guidelines

• Effectively manage the scene with boundaries, exclusion zones, triage areas, etc.
• Evacuate victims and non-essential personnel as quickly as possible.
• Preserve the scene as much as possible for evidence collection and crime investigation.
Prehospital Special Considerations

• **Judicious use of IV fluids:**
  – Overzealous fluid administration may worsen primary pulmonary injury and bleeding

• **Cautious mechanical ventilation:**
  – Mechanical ventilation and positive pressure may increase the risk of alveolar rupture and air embolism
Prehospital Special Considerations

• Cautious air transport

• Air embolization:
  – Place patient in a prone left lateral position with the head down
Mass Casualty Triage

- Dynamic process
- START (Simple Triage And Rapid Treatment)
  - RPM
    - Respirations > 30
    - Pulse Cap refill >2 sec
    - Mental status
- JumpStart for Pediatrics
Triage Categorization

- Red
- Yellow
- Black
- Green
- Immediate
- Delayed
- Dead or expectant
- Minimal
START Triage

RESPIRATIONS

YES

Under 30/min

PERFUSION

Cap refill > 2 sec

Control Bleeding

Immediate

Cap refill < 2 sec.

MENTAL STATUS

Can follow simple commands

Immediate

Non-salvageable

Position Airway

NO

Over 30/min

Immediate

Immediate

Failure to follow simple commands

Immediate

Delayed
Transport

• Transport to the nearest facility of red patients

• Green patients should be directed to other hospitals that are further away and that are not necessarily level I trauma centers
Primary Blast Injury

- Injuries that results from the pressure wave itself
Blast Ear

**Signs and Symptoms**

- Ears ringing
- Hearing loss
- Bloody ears
TM Perforation

• Keep dry
• Prophylactic topical antibiotic
  – Gentamycin suspension
• Outcome is good
  – Mixed frequency hearing loss with good subjective recovery
  – High frequency sensorineural hearing loss may be more persistent
  – Severity inversely proportional to distance from bombing
TM – Perforation

• Follow up is needed:
  – Assess for middle-ear damage
  – Audiometry
  – Cholesteatoma
  – Perilymphatic leak in patients with vertigo
Case Study: Afghanistan

- Friendly fire incident
- 40 casualties
- 9 Americans with TM perforation
- 1 Afghani with TM perforation
Blast Lung Injury

• Should not rely on TM rupture to predict lung injury:
  – TM perforations are found in only 60% of patients with clinically significant injuries
  – Clinically significant injuries are present in less than 30% of patients with TM perforations
Blast Lung

Signs and Symptoms

Chest pain
Bloody/frothy spit
Difficulty breathing
Blast lung Injury

- Patients with normal CXR and ABGs, who have no complaints that would suggest BLI, may be discharged after a brief observation period.

Blast lung Injury

- Management similar to pulmonary contusions
- Complex fluid management
- Mechanical ventilation will increase the risk of air embolization
Blast Belly

Signs and Symptoms

Early:
Belly pain

Late:
Fever
Nausea
Fast heart rate
Management of Secondary Injuries

- As per protocol
- Watch for unusual shrapnel such as nails and bolts
Bombing Victim

Spinal Cord
Management of Tertiary Injuries
Management of Tertiary injuries

• As per trauma protocols
• Look for crush syndrome especially in structural collapse:
  – Myoglobinuria
  – Renal failure
  – Hyperkalemia
Management of Crush Syndrome

- **IVF:**
  - Start in the field
- **Urinary alkalinization:**
  - Myoglobinuria, Urine pH>7
- **Mannitol**
- **Hemodialysis:**
  - Anuric patients, acidemic patients
  - Correction of electrolyte abnormalities
  - Advanced planning is needed for surge capacity
Management of Quaternary injuries

- Inhalational injuries
- Carbon monoxide
- Hydrogen cyanide
- Chemical bombs or explosions
- Contamination with radionuclides and exposure to gamma radiation
Carbon Monoxide

- 100% Oxygen therapy
- Hyperbaric oxygen therapy
Cyanide Antidote Kit

- AKA the Lilly kit
- Contains:
  - Amyl nitrite pearls
  - Sodium nitrite
  - Sodium thiosulfate
How close is too close?
Questions?

Georgia Poison Center