

Mechanisms of Injury
ADVANCED EXPLOSIONS & BLAST INJURIES

Outline

- Injury definitions
- Bomb-Injury threat model
- Agent
- Host
- Environment
- Specific examples
- Review



Blast Factors

- “There can be only 4”
- Water – quick propagation of blast
- Distance – further away is better
- Blast site – open/closed¹
- Reflection – bounce off a wall

¹Plastic explosive clue in Bali bombing BBC News 2002 October 16, Available from URL <http://news.bbc.co.uk/2/hi/asia-pacific/2329189.stm>

Injury Definitions

- **Primary:** blast wave
- **Secondary:** projectile fragments
- **Tertiary:** contact with objects (blunt)
- **Quaternary:** burns and toxins

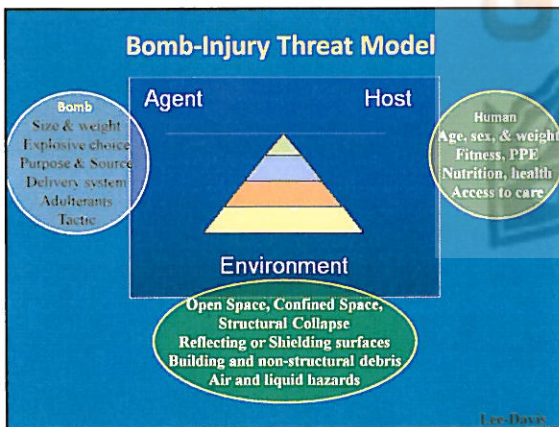
Zuckerman S. Experimental study of blast injuries to the lungs
Lancet 1940,ii 219-24.

Immediate Effects of Blast and Explosions

- Primary - direct effects (e.g., overpressurization and underpressurization)
 - Rupture of tympanic membranes
 - Pulmonary damage
 - Rupture of hollow viscera
- Secondary
 - Penetrating trauma
 - Fragmentation injuries

Immediate Effects of Blast and Explosions

- Tertiary - effects of structural collapse and of persons being thrown by the blast wind
 - Crush injuries and blunt trauma
 - Penetrating or blunt trauma
 - Fractures and traumatic amputations
 - Open or closed brain injuries
- Quaternary - burn, asphyxia, and exposure to toxic inhalants



Agent



500lbs bomb rigged as IED



Anti-Tank Mine encased in concrete and command detonated via remote control



Artillery shells rigged as IEDs

Explosives

- Chemical compound that is able to release stored energy in the form of rapidly expanding gases
 - High Order Explosives (HE)
 - TNT, ammonium nitrate fuel oil, C-4
 - Blast wave
 - Primary blast injury
 - Low Order Explosive (LE)
 - Propellants (black powder, pyrotechnics)
 - No blast wave
 - Rare primary blast injury

High-Order Explosives

- Stored energy is released rapidly
- Detonation
- Examples: TNT, dynamite, shaped charges

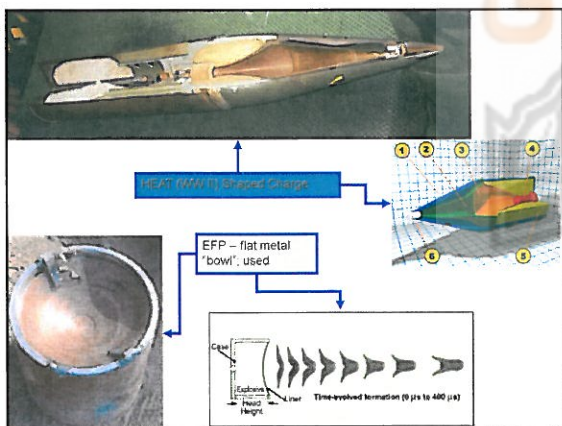
Shaped charges

- Shaped charges^{1,2}
 - Used to focus effect of explosive's energy
- What is an EFP?^{1,2}
 - Explosively formed Projectile/ Penetrator
 - Instead of a cone, it has linear shaped dish
- Why do we care about it?
 - Can penetrate military armor
 - Few countermeasures available
 - Used in IEDs

¹www.GlobalSecurity.org, 2007

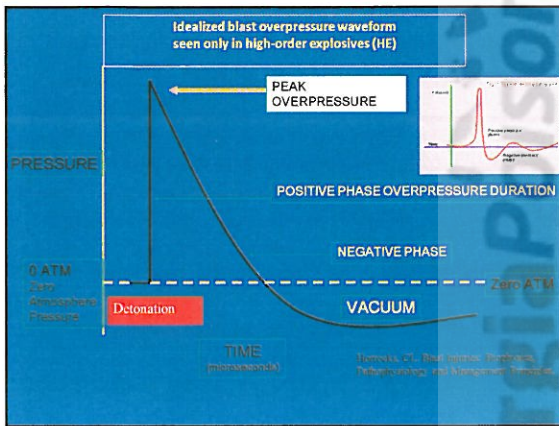
²Explosively Formed Penetrators

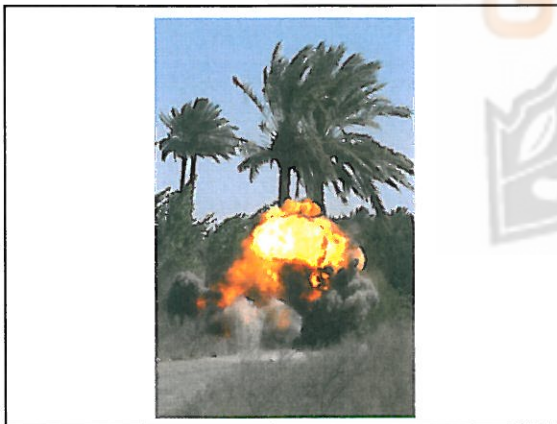
http://en.wikipedia.org/wiki/Explosively_formed_penetrator, 2007

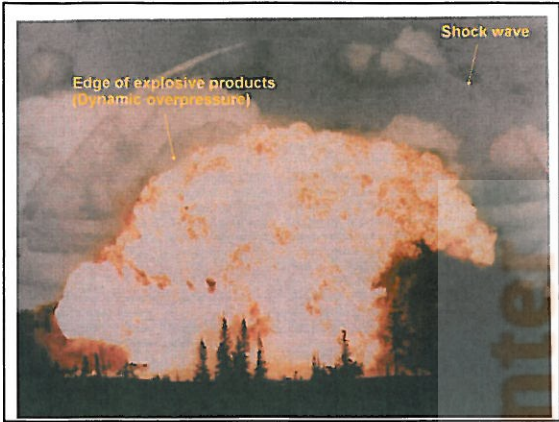


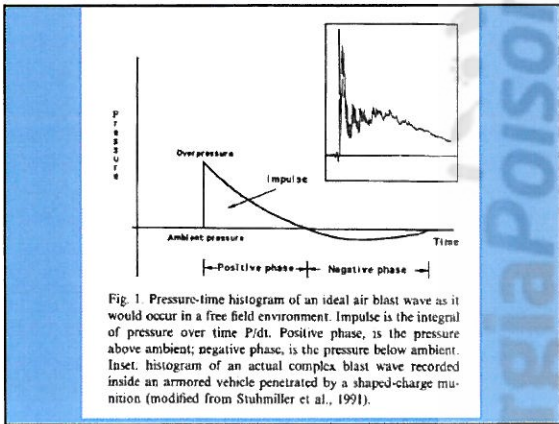
Shaped Charges











- Nuclear video

Low Explosives

- Stored energy is released slowly
- Combustion or deflagration
- Examples: gun powder, fuel
- No blast wave or overpressurization
- Injury results from:
 - Thermal burns,
 - Ballistic (shrapnel)
 - Suffocation (fumes and toxins)

Blast Wind

- Subsonic pressure front
- Generated by high and low-order explosives
- Area of low pressure
- Causes debris and fragments to rush back towards the original explosion

Nevada Atomic Bomb Testing Site - 1955

Film and images at 1 km (0.6 mile) from ~16kT yields

Host

- Age
- Sex
- Height
- Medical history
- Access to care

Environment

- Open space
- Enclosed or confined space
- Structural collapse
- Underwater



Open space

- Potential for shrapnel to travel a large distance (>100 m)
- Less primary blast injuries



Enclosed Space

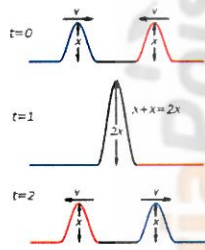
- Increased mortality
- Increased blast pressure
- Complicated rescue



Leibovici D. Blast injuries: bus versus open-air bombings—a comparative study of injuries in survivors of open-air versus confined-space explosions. J Trauma 1996,41: 1030-5.

Blast Wave in Enclosed Space

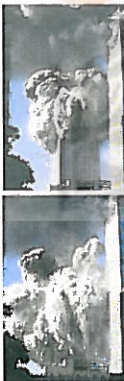
- Wave reflects over surfaces:
 - Creates complex waves
 - Greater in amplitude
 - Expose the body for a longer period



Wikimedia Commons

Structural Collapse

- Increased mortality from primary blast wave as well as from tertiary and quaternary injuries
- Crush syndrome

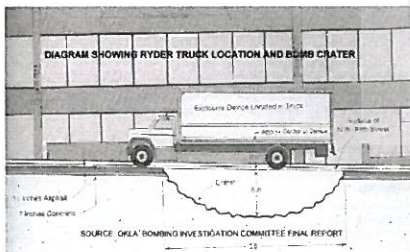


Who is this?

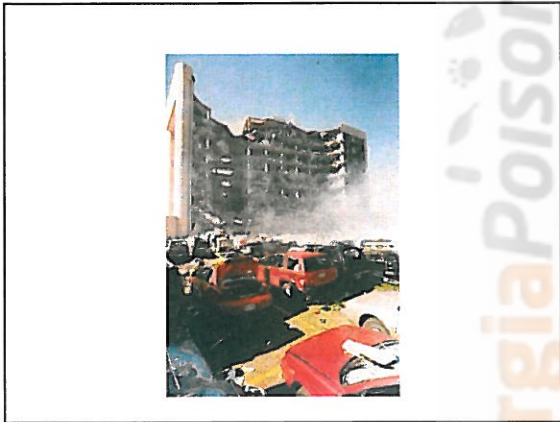


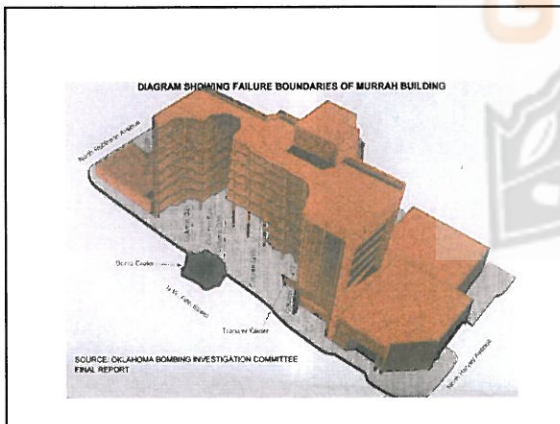
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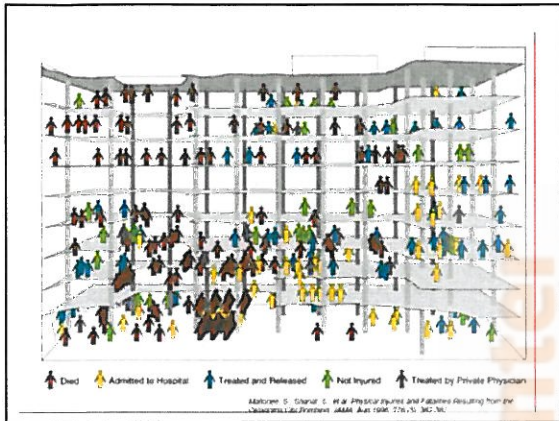












Questions or Comments?

Georgia Poison Center
TRAINING

