

A photograph of a man from behind, wearing a black t-shirt with white text. The text reads: 'I AM A BOMB TECHNICIAN IF YOU SEE ME RUNNING TRY TO KEEP UP'. The man is standing in a public area, possibly a train station, with other people and a yellow wall visible in the background.

**I AM A
BOMB
TECHNICIAN
IF YOU SEE ME
RUNNING
TRY TO
KEEP UP**

Conventional Bombs

Bombings and explosions

- the method that most commonly has been used by terrorists
- is most likely to result in the largest numbers of casualties and destruction of property

- IRA Bombs, U.K 1970s
- PLO in Israel 1970s
- Bologna, Italy 1980
- U.S. Marines, Beirut 1983
- Paris Bombings 1986
- Lockerbie Pan Am crash 1988
- World Trade Centre 1993
- AMIA, Buenos Aires 1994
- Oklahoma City 1995
- Atlanta Olympics 1996
- U.S. Embassies, Africa 1998
- World Trade Center Collapse 2001
- *Assasination of Rajiv Gandhi by suicide bomber*

- **10 fold increase** in terrorist bombing incidents worldwide between *1968* and *1980*
- 5,075 events documented *1973 to 1983*
- **3,689 deaths**
- 7,991 injuries

NOT IF, BUT WHEN

- Two measures of each terrorist bomb event-

- Casualty generation (*total number of injured and killed*)

- Magnitude of explosion
- Number of people in the vicinity

- “Lethality” (*proportion of casualties killed*)

- Indoor vs outdoor
- Building collapse

Blast Injuries

Primary blast injury

Blast wave effects

Sudden change in atmospheric pressure

Depends on setting (indoor or outdoor)

Secondary blast injury

Classic shrapnel injuries

Blast Injuries

- **Tertiary blast injury**

Injuries that result from secondary impacts after the blast wave has propelled patient

Miscellaneous blast injury

Smoke

Burns

Inhalation injuries

- IRA

- self detonating (timer)
- Remote control detonation

- Israel and PLO (Iraq)

- Suicide bombers

Suicide bombings

- Israel Experience
- From Nov 2000 to May 2003,
 - there were 71 suicide bombings
 - Open Space
 - Buses
 - Semi-confined space (restaurants, cafes)

Suicide bombings

- High grade explosive material used
- Ability to detonate in close proximity to victims
- Ability to precisely time the explosion
- Large load of heavy shrapnel as well as the explosive material

- Suicide Bomb victims suffer with the worst of both
 - ie Explosion and Penetrating shrapnel

Suicide bombings

- Israel Experience
- From Nov 2000 to May 2003,
 - Open Space - 15 % mortality
 - Semi-confined space (*restaurants, cafes*)
 - Confined space (*buses*) - 40 % mortality

Penetrating vs Explosive Injuries

- Israel Trauma Registry
 - 54 % explosion victims
 - 35 % gunshot victims
- Brain, Head, Pelvis and Limbs – more common injuries in explosions
- Chest, Abdomen, and Spine – more common in gunshot wounds
- Multiple regions more likely with explosions
- Open wounds – more common in gunshots

Penetrating vs Explosive Injuries

- Israel Trauma Registry
 - Burns – 8.8 %
 - All in explosion victims
 - 68 % of burn patients also had penetrating or blunt injuries or both
 - ICU Admission – 23 % (Explosion = Gunshot)
 - LOS longer with victims of explosions

Penetrating vs Explosive Injuries

- Israel Trauma Registry

51 % of Gunshot victims needed surgery

46 % of Explosion victims needed surgery

Equal mortality rates of **6.3 %**

(Early deaths in gunshot victims within 7 days)

Type and Severity of Injury

- Depends on indoor or outdoor
- Collapse of structures, buildings
- Enhanced wounding measures
 - Ball bearings, nails, incendiary

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Primary Blast Injury

Most severe closest to epicenter of the blast

Sudden change in pressure devastates air and fluid filled organs and cavities



Essentially
BAROTRAUMA

Primary Blast Injury

Ability to cause damage to the body depends on:

- Peak Pressure
- Duration of the overpressure wave



Essentially
BAROTRAUMA

Primary Blast Injury

Ability to cause damage to the body depends on:

➤ Peak Pressure

short pulse – milliseconds
exponential decay with
time and distance
water vs air
Open vs Closed space

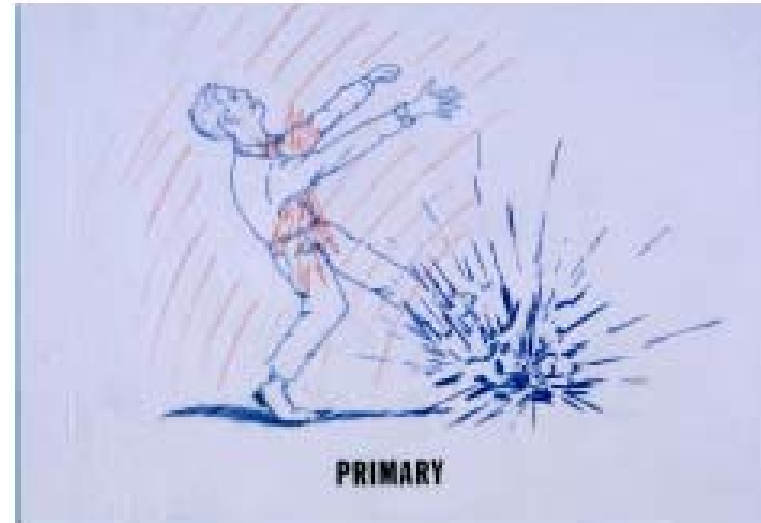


Primary Blast Injury

Shock Wave

3 Distinct Components

- Initial **High positive pressure** phase (short)
- Second, **milder negative pressure** phase (longer)
- Third – Blast Wave (**mass movement of air**)



Essentially
BAROTRAUMA

- Ruptured Tympanic membrane
- Blast Lung Injury
- Intestinal or other hollow viscera injury
- Direct brain injury

Paucity of obvious external signs !

Ruptured Tympanic membrane

Most sensitive organ in barotrauma

- As little as 5 psi above atmospheric pressure
- Temporary neuropraxia is common
- Permanent hearing loss can occur with disruption of the oval or round windows in the cochlea
- Spontaneous healing in 50 % to 80 %
- Symptoms – ‘deafness, tinnitus and vertigo’

Blast Lung Injury (BLI)

- Second most susceptible organ
- Direct consequence of blast wave on the body
- Overpressure needed is about 40 psi
 - At 80 psi- 50 % have severe pulmonary damage (*at 200 psi-fatal*)
- Most common **CRITICAL** Injury in victims close to bomb
- Can be life threatening
- May not have obvious external injury to the chest
- Can be associated with pneumothorax, haemothorax
- **Air embolism** from pulmonary disruption (fatal)

Blast Lung Injury (BLI)

- Results in tearing, haemorrhage, contusion and oedema
- Microhaemorrhages in alveoli
- Disruption and weakening of alveolar walls
- Disruption of perivascular and peribronchial tissue
- Resultant Ventilation-Perfusion mismatch

Blast Lung Injury

- **Symptoms:** Dyspnoea, Haemoptysis, cough, chest pain
- **Signs:** Tachypnoeic, hypoxic, cyanosis, wheezing
- **X-Ray** features similar to pulmonary contusion, with bihilar (butterfly pattern) shadows
- Can be life threatening
- Can be associated with pneumothorax, haemothorax
 - Can have bronchopleural fistula
 - Air embolism from pulmonary disruption
- Other injuries may add to haemodynamic instability

Blast Lung Injury *(management)*

- Standard Trauma triage, resuscitation protocols
- management like that of pulmonary contusion in trauma
 - judicious fluid use for adequate organ perfusion without overload
- Oxygen- from high flow, non-rebreather mask to CPAP or intubation
- May benefit from selective (double lumen) tube
- Positive Pressure ventilation may increase risk of alveolar rupture and air embolism
- Ventilation – High frequency Jet ventilation
 - Permissive hypercapnia

Blast Lung Injury (*disposal from scene, ed*)

- Established BLI management is complex- often requires ICU admission (or high dependency area)
- Others with complaints or suspicion of BLI should be observed in hospital
- If normal CXR and ABGs - can be discharged after 4-6 hours observation
- Little long term outcome data on BLI
- One study showed no further problems one year later

Blast Hollow Visceral Injury

More common in underwater explosions

- Colon is more frequently involved than small bowel
- Mesenteric haemorrhage
- Delayed rupture of bowel (high mortality in combination with blast lung)

OTHER

Rupture of the **eye** (globe) - {10% to 28% have eye injuries}

Primary blast injury to the brain

concussion, contrecoup injuries

Traumatic amputations can occur in people within 1 metre of the blast

Can cause **placental abruption**: Fetus is well protected.

Secondary Blast Injury

- Injury from flying debris
- Classic shrapnel injuries of various velocities
- **Manage as standard penetrating trauma**
- #1 Military killer in the 20th Century



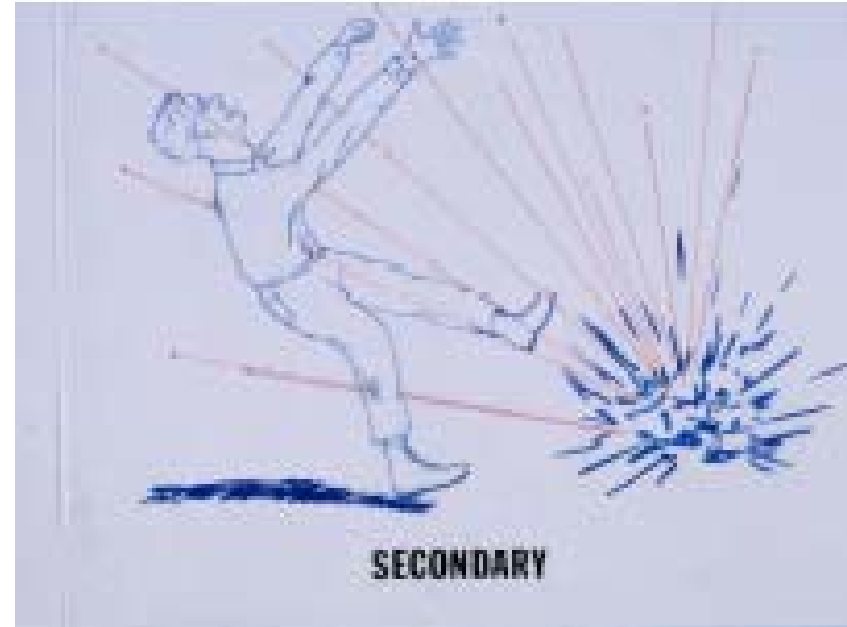
More Common than primary blast injury because victim does not have to be near the explosion

Secondary Blast Injury

Primary bomb fragments

Secondary fragments or
missiles

London described cases of
biological secondary
fragments *(need for infection
counselling)*



Tertiary Blast Injury

- Axial load injuries
- Manage as standard blunt injury
- Wide-range of blunt trauma injuries:
 - Spine
 - Orthopaedic
 - Head
 - Solid and hollow organ injuries
 - Crush syndrome



Miscellaneous Blast Injury (*Quaternary*)

- Inhalation injuries
 - from dust and gases
- Burns
 - Thermal
 - Radiation

Medical management issues

- External clinical signs of injury can be absent
- Primary blast lung and blast abdomen are associated with a high mortality rate
- Blast lung presents soon after explosion
- Blast Lung injury is unlikely without Tympanic membrane rupture. (useful for screening)
- Wounds are often contaminated

Medical management issues

- Multiple shrapnel wounds are usually shallow and don't require surgery
- Tetanus prophylaxis
- Do **NOT** suture contaminated wounds
- Consider Air embolism and hyperbaric therapy
- Screen for inhaled toxins, Carbon monoxide

Medical management issues

- Triage by surgeons in the emergency department and before surgery
- Upside down triage is common
- Careful balance between management of burns and blast injury (*fluid management is complex*)
- *Children – use more ICU resources*

Mass Casualty management issues

- Triage area OUTSIDE of emergency department
 - Need portable auroscopes, pulse oximetres etc.
- Use mid level staff for triage
- Allocate separate area for minor injuries
- Constant review of “minor injuries”
- Military Triage may be required
 - ‘Greatest good for the greatest number’

Communication with patient

- at Scene and in the Hospital
- All Instructions must be written if possible
 - Hearing impaired because of tinnitus or due to sudden temporary or permanent deafness.

Category	Characteristics	Body Part Affected	Types of Injuries
Primary	<p>Unique to HE, results from the impact of the over-pressurization wave with body surfaces.</p> <p><i>HE - High-order Explosives</i></p>	<p>Gas filled structures are most susceptible</p> <ul style="list-style-type: none"> - lungs, GI tract, and middle ear 	<ul style="list-style-type: none"> - Blast lung (pulmonary barotrauma) - TM rupture and middle ear damage - Abdominal hemorrhage and perforation - Globe (eye) rupture - Concussion (TBI without physical signs of head injury)
Secondary	Results from flying debris and bomb fragments	Any body part may be affected	<ul style="list-style-type: none"> - Penetrating ballistic (fragmentation) or blunt injuries - Eye penetration (can be occult)
Tertiary	Results from individuals being thrown by the blast wind	Any body part may be affected	<ul style="list-style-type: none"> - Fracture and traumatic amputation - Closed and open brain injury
Quaternary	<ul style="list-style-type: none"> - All explosion-related injuries, illnesses, or diseases not due to primary, secondary, or tertiary mechanisms. - Includes exacerbation or complications of existing conditions. 	Any body part may be affected	<ul style="list-style-type: none"> - Burns (flash, partial, and full thickness) - Crush injuries - Closed and open brain injury - Asthma, COPD, or other breathing problems from dust, smoke, or toxic fumes - Angina - Hyperglycemia, hypertension

Table 2: Overview of Explosive-related Injuries

System	Injury or Condition
Auditory	TM rupture, ossicular disruption, cochlear damage, foreign body
Eye, Orbit, Face	Perforated globe, foreign body, air embolism, fractures
Respiratory	Blast lung, hemothorax, pneumothorax, pulmonary contusion and hemorrhage, A-V fistulas (source of air embolism), airway epithelial damage, aspiration pneumonitis, sepsis
Digestive	Bowel perforation, hemorrhage, ruptured liver or spleen, sepsis, mesenteric ischemia from air embolism
Circulatory	Cardiac contusion, myocardial infarction from air embolism, shock, vasovagal hypotension, peripheral vascular injury, air embolism-induced injury
CNS injury	Concussion, closed and open brain injury, stroke, spinal cord injury, air embolism-induced injury
Renal Injury	Renal contusion, laceration, acute renal failure due to rhabdomyolysis, hypotension, and hypovolemia
Extremity injury	Traumatic amputation, fractures, crush injuries, compartment syndrome, burns, cuts, lacerations, acute arterial occlusion, air embolism-induced injury