Blast injury

BY

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1st course surgery

High-Yield Explosives

- Military grade (for example, C4, Hand-grenades, landmines, and explosive artillery shells)
- Commercial grade explosives

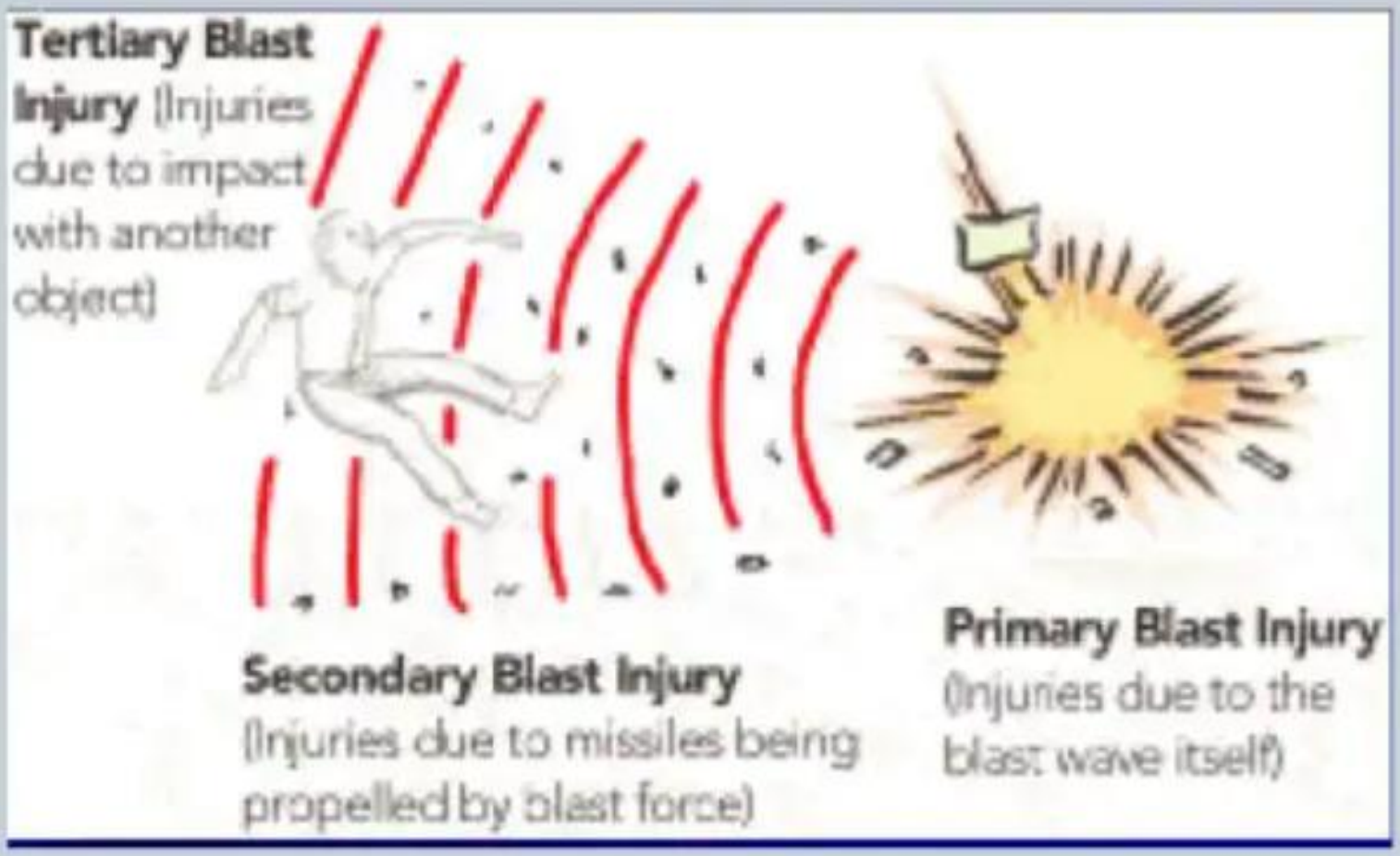
  Primary high explosives (for example, nitroglycerin, lead azide and tetrazene)

  Secondary high explosives (for example, TNT and dynamite)
- Non-conventional (for example, nitrogen-fertilizer mixes and calcium carbide)

M&M

- Injury patterns are dependent on factors such as:
- Composition and the amount of explosive used
- Location of the detonation
- Surrounding environment
- Distance between the victim and the blast
- Any intervening protective barriers or environmental hazards

Effects of Blast



Injuries from explosions are traditionally classified into:

1. **Primary blast injuries:** injuries due solely to the blast wave
2. **Secondary blast or explosive injury:** primarily ballistic trauma resulting from fragmentation wounds from the explosive device or the environment
3. **Tertiary blast or explosive injury:** result of displacement of the victim or environmental structures, is largely blunt traumatic injuries
4. **Quaternary explosive injuries**: burns, toxins, and radiologic contamination


Pathophysiology

Pathophysiology

- The blast wave enters the body creating two types of energy, **stress waves** and **shear waves.**
- **Stress waves** are longitudinal pressure forces that move at supersonic speeds and create a "spalling" effect at air–tissue interfaces, much like boiling water, resulting in severe microvascular damage and tissue disruption.
- **Shear waves** are transverse waves that cause asynchronous movement of tissue and possible disruption of attachments.

Pathophysiology

- The organs most likely affected by primary blast injury are the ears, lungs, and colon or gas-filled organs with the damage originating at the tissue–gas interface.
- Ruptured tympanic membrane, ossicular disruption, alveolar hemorrhage, cerebral, coronary, retinal and lingual air emboli, ruptured viscus with pneumoperitoneum, and vagally mediated bradycardia, apnea, and hypotension are among the early signs of severe primary blast injury.

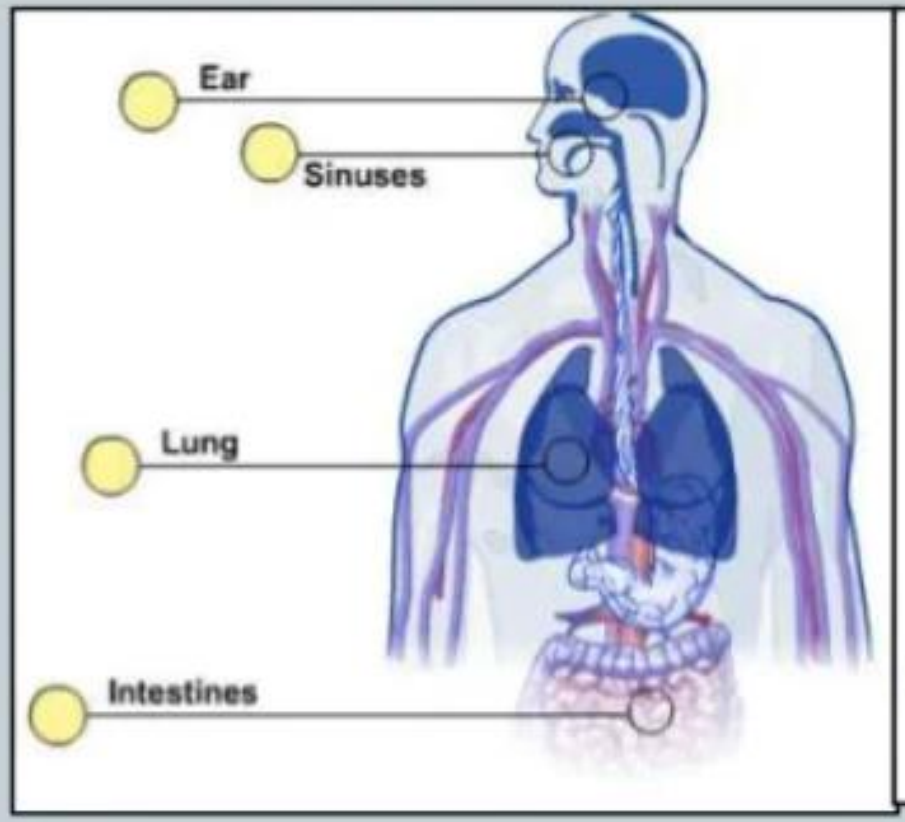
Pathophysiology

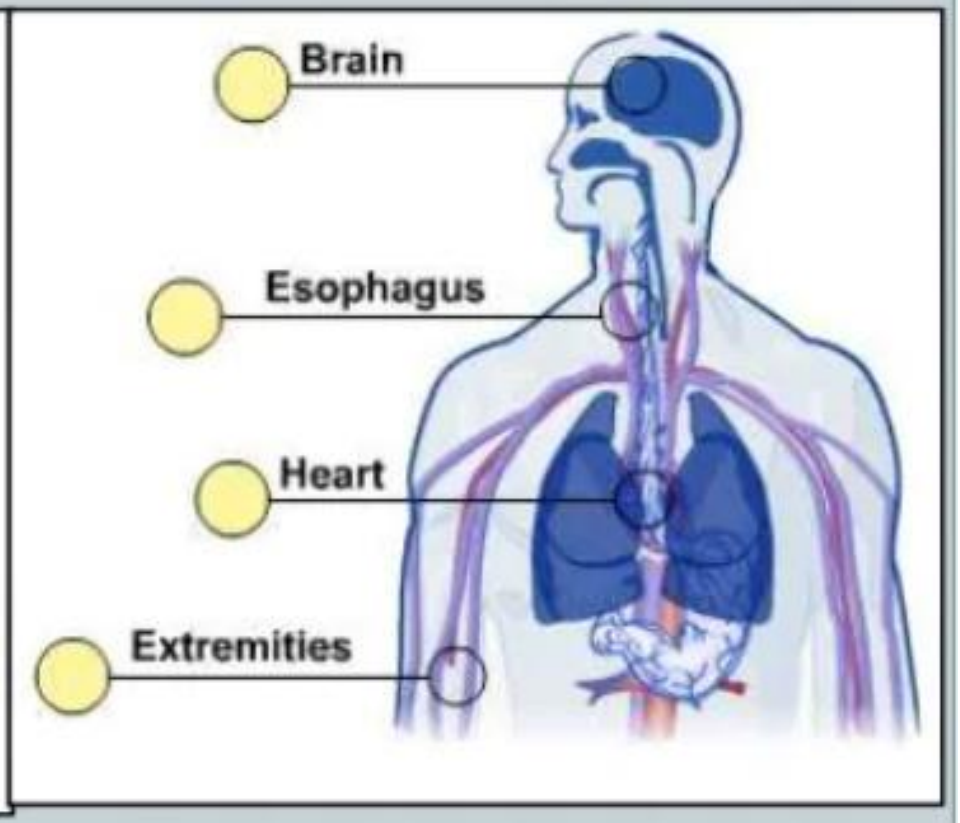
- The absence of **perforation of the tympanic membrane** and lack of **petechiae in the oropharynx** have been said to mediate against primary blast injury of internal organs in the majority of cases.
- The presence of **oral petechiae and perforated tympanic membrane** together, this can be a **valuable triage tool** to alert the physician to keep a patient for further observation.

Primary Blast Effects

- Unique to high-order explosions
- Form of barotrauma
- Gas filled organs with structures are most susceptible
- Types of injuries:
  - Blast lung
  - Tympanic membrane (TM) rupture and middle ear damage
  - Abdominal hemorrhage
  - Globe rupture
  - Traumatic Brain Injury (TBI)
  - Amputations

Primary Blast Effects





Secondary Blast Effects

- Penetrating trauma caused by acceleration of shrapnel or blast debris
- Any body part can be affected
- Responsible for the majority of the casualties
- Types of injuries:
  - Penetrating ballistic (fragmentation)
  - Blunt injuries
  - Eye injuries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Tertiary Blast Effects

- Occurs when victim is propelled through the air
- Typical patterns of blunt trauma occurring on impact with a solid object or the ground
- Blast wind may propel a 75kg adult with an acceleration of close to 15G's
- Any body part could be affected
- Types of injuries:
  - Fracture and traumatic amputation
  - Closed and open brain injuries

Quatenary Blast Injuries

- All explosion related injuries, illnesses, or diseases which are not due to the other three categories
- Injuries primarily include exacerbation or complications of existing conditions
- Types of injuries:
  - Burns
  - Crush injuries
  - Closed or open brain injuries
  - Restrictive Airway Disease, Acute Respiratory Distress (ARD) syndrome, or other breathing problems from dust, smoke, or toxic fumes

Quinary Blast Effects

- Refers to the clinical consequences of "post detonation environmental contaminants" including:
  - Bacteria (deliberate and commensally, with or without sepsis)
  - Radiation (dirty bombs)
  - Tissue reactions to fuel and metals
- Types of injuries:
  - Infections
  - Contamination
  - Fragmentation wounds

Primary

Pulmonary Injury Symptoms

- Most often, blast effect on the lungs results in a "shock lung." This may range from mild, pleuritic chest pain with radiographic evidence of ARDS, but with normal oxygenation; through pneumothorax or hemopneumothorax; to full blown ARDS with hypoxemia and relatively normal to deranged carbon dioxide levels.

Pulmonary Injury Treatment

- Treat mild shock lung conservatively, while closely following the patient for deterioration of pulmonary function or evidence of hypoxemia.
- If patient's condition continues to worsen, intubation and assisted ventilation with PEEP may be required.


Collapsed lung
Absent vascular markings

Primary

Gastrointestinal Injury Symptoms

- Clinical signs of abdominal injuries may be absent until the onset of complications. The colon is the most common site of both hemorrhage and perforation.
- Symptoms that may indicate abdominal injury include:
  - Nausea
  - Vomiting
  - Rectal pain
  - Hematemesis
  - Tenesmus
  - Testicular pain
  - Unexplained hypovolemia

Primary

Gastrointestinal Injury Treatment

- Computed Tomography (CT) scans or abdominal x-ray series should be done if abdominal pain persists and vomiting develops.
- Symptoms of pulmonary contusion and intestinal hematoma may take 12 to 48 hours to develop, and the CT scans or x-rays may not be able to make an early detection.

Secondary

- Fragments or other shattered objects may travel at initial speeds of up to 5,000 feet/second
- Injuries may be minimal or extensive, penetrating any part of the body
- Neck, chest, and abdominal wounds are a frequent cause of death
- May also produce other hazards by severing electrical lines, rupturing tanks or gas lines, and further weakening structures

Secondary

Fragment Injuries

Symptoms

- Wounds caused by fragmented material traveling at a high rate of speed
- Injuries may be minimal to severe.
- Penetrating wounds are a frequent cause of death.
- Metal fragments pose the additional risk of producing heavy metal poisoning.

Treatment

- Should be treated as high-velocity missile injuries.
- Contaminated wounds must be decontaminated before being treated.
- Contaminated wounds with heavy metal that cannot be removed may
- require patient to be returned for observation and follow-up assessment.

Tertiary

- Occur as objects flying from the blast hit victims.
- Blast winds may cause victims to become flying objects themselves
- It is rare that victims are thrown through the air and suffer secondary blunt or penetrating trauma
  - Most frequently, victims sustain cuts, bruises, abrasions and fractures from tumbling along the ground

Quaternary

Thermal Effects

- Primary thermal effects are the least common of the effects of explosives.
- Occur only to people closest to the blast
- Unless caught in the fireball, or a secondary fire, most thermal injuries are superficial flash burns as from clothing that catches fire

Quaternary

Thermal Injuries

Symptoms

- Primary thermal injuries are usually first- or second-degree "thickness burns" unless clothing is ignited.
- Victims enclosed in structures may suffer not only severe thermal burns, but may develop thermal inhalation injuries.

Treatment

- Thermal injuries due to explosions should be treated as any burn.
- Topical antibiotics and silver impregnated dressings reduce the likelihood of secondary infections.
- Inhalation injuries will require rapid intubation prior to onset of airway edema.

Quaternary

- Crush injuries are the result of a compressed force crushing the fascia-encapsulated muscle groups.

Symptoms

- Crush injuries may result in:
  - compartment syndrome of the upper or lower extremities,
  - muscle necrosis,
  - hyperkalemia,
  - myoglobinuria,
  - possible renal failure

Quaternary

Treatment

- Check serum and urinanalysis in any patient entrapped as the result of an explosion.
- If renal function is intact, hyperkalemia will correct itself without treatment unless severe.
- Myoglobinuria treatment centers on preventing myoglobin precipitation in the urine by maintaining a brisk alkaline diuresis.
  - Administer saline loading immediately to patients with volume depletion.
  - Consider follow up with mannitol to induce a diuresis, supported by adequate IV fluids.

Blast Lung

- The instantaneous rise in pressure caused by blast wave induces injury by two basic mechanisms:
  - (1) compression and deformation of the chest wall by pressure wave
  - (2) direct transmission of the blast wave into the body causing damage by spalling, implosion and inertia.

Blast Lung

- The most frequent and life threatening injury is acute pulmonary hemorrhage from disruption of the alveolar septa and pulmonary capillaries.
- Lung injury is a major cause of death in patients who survived initial resuscitation after exposure to Blast Over Pressure (BOP).
- Blast lung injury can cause severe hypoxemia, which can be improved significantly with supplemental oxygen.

Blast Lung: Experimental Model

- The most consistent lesions after exposure to 120 kPa BOP were scattered surface petechiation and hemorrhage.
- Survival rate in animals exposed to 120 kPa BOP was 90%.
- In the lungs 2 hours postblast:
  - trace injury and petechial surface spots.
- 24 and 48 hours postexposure:
  - intensity of lung injury progressed to moderate level
    - scattered hemorrhagic lesions.
- Later, lung lesions disappeared and at 192 hours postexposure there were no visible signs of injury.

Blast Lung Injury Treatment

- **Tube thoracostomy alone is adequate treatment for most simple lung parenchymal injuries.**
- Large air leaks not responding to chest tubes or that do not allow adequate ventilation will require open repair (see tracheobronchial tree below).
- **Posterolateral thoracotomy** is preferred for isolated lung injuries. Anterior thoracotomy may also be used.

Blast Lung Injury Treatment

- Control simple bleeding with absorbable suture on a tapered needle. Alternatively, staples (TA-90) may be used for bleeding lung tears.
- Resection for bleeding may be indicated with severe parenchymal injury.
- Anatomic resections are **not indicated** and simple stapled wedge excisions recommended.
- Uncontrolled parenchymal/hilar bleeding, or complex hilar injuries with massive air leak should be controlled with hilar clamping and repair attempted.
- Pneumonectomy is performed as a last resort (90% mortality).


THANK
YOU