Classification

1. **Primary blast injury:**
2. **Secondary blast injury:**
3. **Tertiary blast injury:**
4. **Quaternary blast injury**:

Classification

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

Classification

Pathophysiology

Pathophysiology

- Blast wave injury produces **stress waves** and **shear waves**
- **Stress waves**
- **Shear waves**

Pathophysiology

- Blast wave injury produces **stress waves** and **shear waves**
- **Stress waves**
  - longitudinal pressure forces
  - resulting in severe microvascular damage and tissue disruption over air–tissue interfaces
- **Shear waves**
  - transverse waves
  - cause asynchronous movement of tissue and possible disruption of attachments.

Pathophysiology

- Name the organs that are most affected by primary blast injury

Pathophysiology

- Name the organs that are most affected by primary blast injury
  1. Ears
  2. Lungs
  3. Colon or gas-filled organs

Pathophysiology

- Early signs of severe primary blast injury

Pathophysiology

- Early signs of severe primary blast injury
  - Ruptured tympanic membrane
  - Ossicular disruption
  - Alveolar hemorrhage
  - Cerebral, coronary, retinal and lingual air emboli
  - Ruptured viscus with pneumoperitoneum
  - Vagally mediated bradycardia, apnea, and hypotension

Pathophysiology

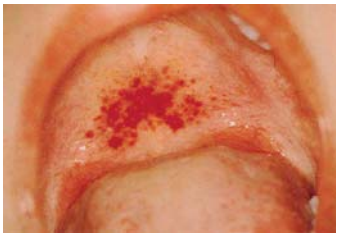
- Name 2 **valuable signs** that indicate the presence of injuries to the internal organs

Pathophysiology

- Name 2 **valuable signs** that indicate the presence of injuries to the internal organs
  - (1) perforation of the tympanic membrane
  - (2) petechiae in the oropharynx
- These signs alert the physician to keep a patient for further observation

The two valuable signs

- **(1) perforation of the tympanic membrane**
- **(2) petechiae in the oropharynx**



Ocular Injury

- 10% of all blast survivors
- Symptoms:
  pain or irritation, altered vision, periorbital swelling, contusion, or foreign body sensation
- Signs:
  conjunctival hemorrhage, diminished visual acuity, hyphema, globe rupture, presence of foreign body, or lid lacerations

Ocular Injury

- Ophthalmology consultation
  - Suspected globe injuries
  - Corneal foreign bodies or abrasions
  - Orbital fractures
  - Retinal detachments
  - Hyphema
  - Intraocular foreign bodies
  - Corneal or eyelid burns
  - Lid lacerations
  - Subconjunctival hemorrhage

Aural Injury

- TM rupture = most common PBI (9~47%)
  - hearing loss, tinnitus, pain, and dizziness
- All explosion victims should be evaluated with an otoscopic examination

Blast Lung Injury

- Incidence: 3~14%
- BLI is the most common fatal injury among initial survivors of explosions
- Types of BLI:
  - Minor or massive parenchymal hemorrhage
  - Pulmonary edema
  - Pneumothorax
  - Air embolism from alveolovenous fistulas

Blast Lung Injury

- S:
  - Tachypnea, dyspnea, cyanosis, and hemoptysis
- O:
  - Diminished breath sounds
  - Crepitance (subcutaneous air)
  - Abnormal breath sounds
  - Hypoxia (oxygen saturation <90%) - reaches nadir within the first 24h

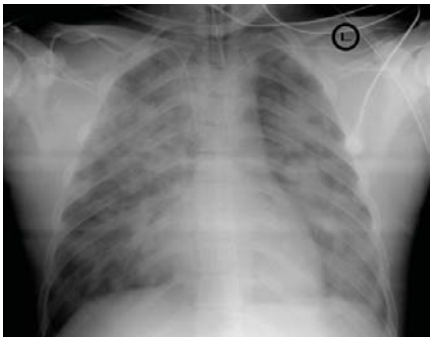
Blast Lung Injury

- Clinical:
  - Respiratory distress
  - Hypoxia
- CXR:
  - 1. "Butterfly" or "batwing" infiltrates
  - 2. Pneumothorax
  - 3. Pneumomediastinum

Blast Lung Injury - management

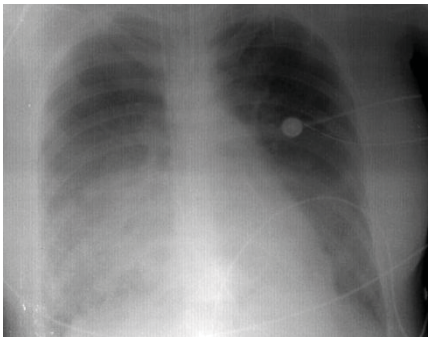
- Avoid positive pressure ventilation
- Ventilator settings:
  - Pressure-limited, volume-controlled ventilation with permissive hypercapnia
  - Minimize PEEP ventilation
- Judicious fluid resuscitation strategies
- When all else fails, consider ECMO

Blast Lung Injury



"Butterfly" or "batwing" infiltrates

Blast Lung Injury



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Blast Lung Injury

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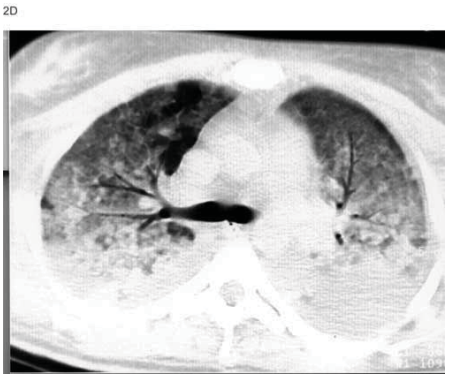
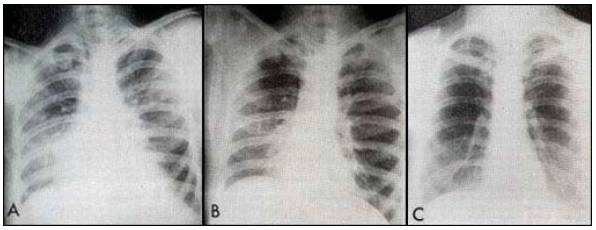
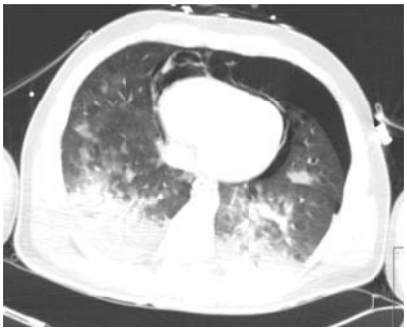


Blast Lung Injury



Blast Lung Injury



Pneumothorax, pneumomediastinum

Intestinal Blast Injury

- Rare, incidence: 0.3~0.6%
- Abdominal viscera PBI:
  - Abdominal pain, nausea, vomiting
  - Hematemesis, melena
  - Peritoneal signs of injury
  - Hemodynamic instability

  1. mesenteric hemorrhage
  2. solid organ injury

Intestinal Blast Injury

- Radiographic evidence:
  - Pneumoperitoneum
  - Free intraperitoneal fluid
  - "Sentinel clot" adjacent to bowel wall or mesentery
- Mesenteric / mural hematoma:
  - If hemodynamically stable without peritoneal signs, may be managed with NPO, NG decompression, and resuscitation
- Massive hemorrhage / hollow viscus perforation:
  - Laparotomy indicated

Cardiovascular Effects of Blast

- Triad (vagally mediated):
  1. Immediate bradycardia
  2. Hypotension
  3. Apnea
- The most common arrhythmias: Bradycardia, VPCs and asystole
- Hypotension - associated with low cardiac index and stroke volume but normal systemic vascular resistance

Cardiovascular Effects of Blast

- Hemorrhaging explosion-injured patients may not have the expected compensatory tachycardia and may become hypotensive
-
- Atropine may be a useful adjunct in patients with blast-induced bradycardia

Traumatic Amputations

- Principles:
  - Control extremity hemorrhage
  - Early tourniquet use should be applied
  - High clinical suspicion for occult injuries to the CNS, thorax, and abdomen

Early tourniquet

Early tourniquet

Traumatic Brain Injury

Traumatic Brain Injury

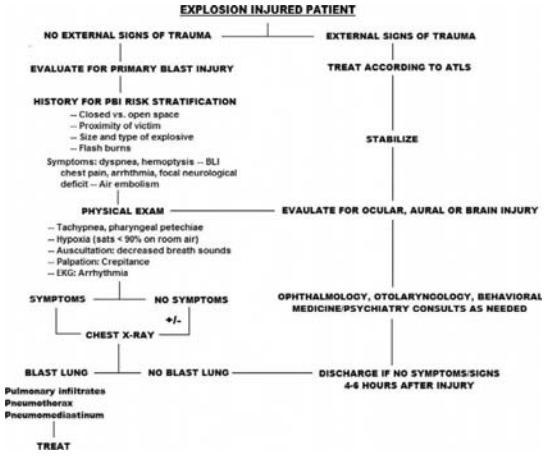
- Kinetic energy transfer causes shearing, resulting in diffuse or focal axonal injury
- Both acute and delayed symptoms of post-concussion syndrome or PTSD
  - **Psychologic**: excitability, irrationality, retrograde amnesia, apathy, lethargy, poor concentration, insomnia, psychomotor agitation, depression, anxiety
  - **Physical**: fatigue, headache, back and diffuse pains, vertigo, transient paralysis, and "heavy" feeling extremities

Traumatic Brain Injury

- Physical examination:
  Romberg's sign and funduscopy (air emboli)
- CT scan:
  Search for evidence of blunt head injury and ICH

Patient Risk Stratification

1. **Explosive device** details:
   Type and weight of explosive, improvised vs. commercially available, suicide bomber, time of detonation
2. **Geography**:
   Device location, open vs. closed space detonation, surrounding structures (urban vs. rural setting)
3. **Victim**:
   Distance and location of the victim in relation to explosive and surrounding structures, personal protective equipment
4. **Status of other casualties**:
   Cause of any on-scene deaths, primary blast injury in other surviving victims



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Post-test