

# Bomb, Blast Injuries

**MASOMEH NAZEMI.MD**

**Emergency Medicine Specialist  
Kerman University of Medical Sciences**

# EPIDEMIOLOGY

- Terrorist attacks **have increased** dramatically over the last decade.
- Most emergency physicians **have never encountered** a blast injury victim or a true mass casualty incident.
- Terrorist bombings use **higher hospital resource**

# EPIDEMIOLOGY

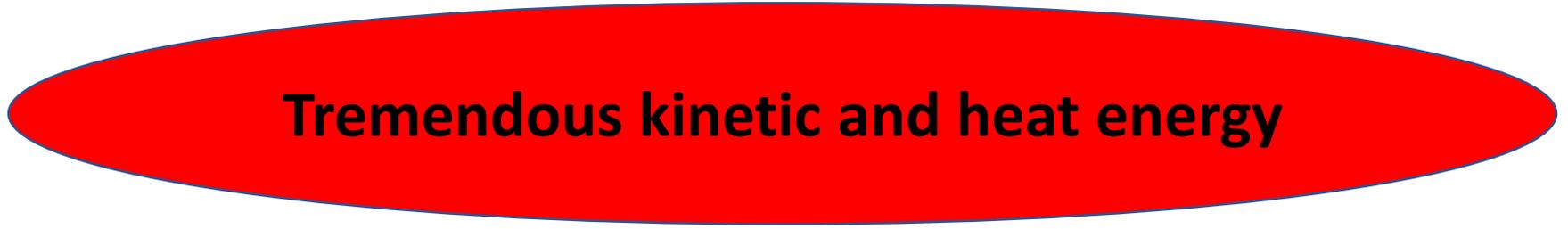
- Blast victims have
  - ✓ Increased immediate scene mortality
  - ✓ Greater hospital mortality
  - ✓ More frequent need for surgical intervention
  - ✓ Longer hospital stays
  - ✓ Greater use of critical care

# PATHOPHYSIOLOGY

An explosion a solid or liquid

Gas

Tremendous kinetic and heat energy



# PATHOPHYSIOLOGY

The blast wave consists of two parts:

1. A shock wave of high pressure
2. A blast wind, which is air mass in motion



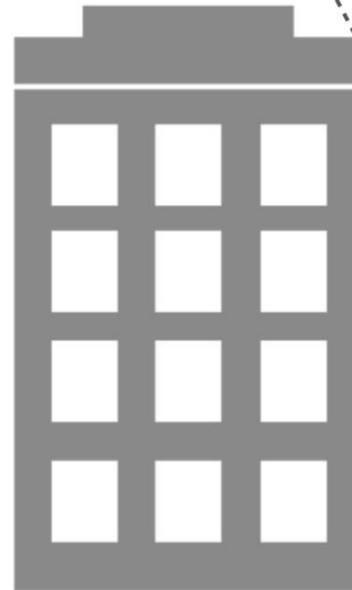
# BLAST INJURIES

There are four main types of blast effects.

- A primary injury
- A secondary injury
- A tertiary blast injury
- A quaternary blast injury

## Tertiary

- Person propelled into solid object
- Crush injuries common



## Secondary

- From objects propelled by the blast
- Significant source of casualties
- High risk of infection



## Primary

- From Blast Wave
- Damage at air-fluid interfaces
- Significant mortality



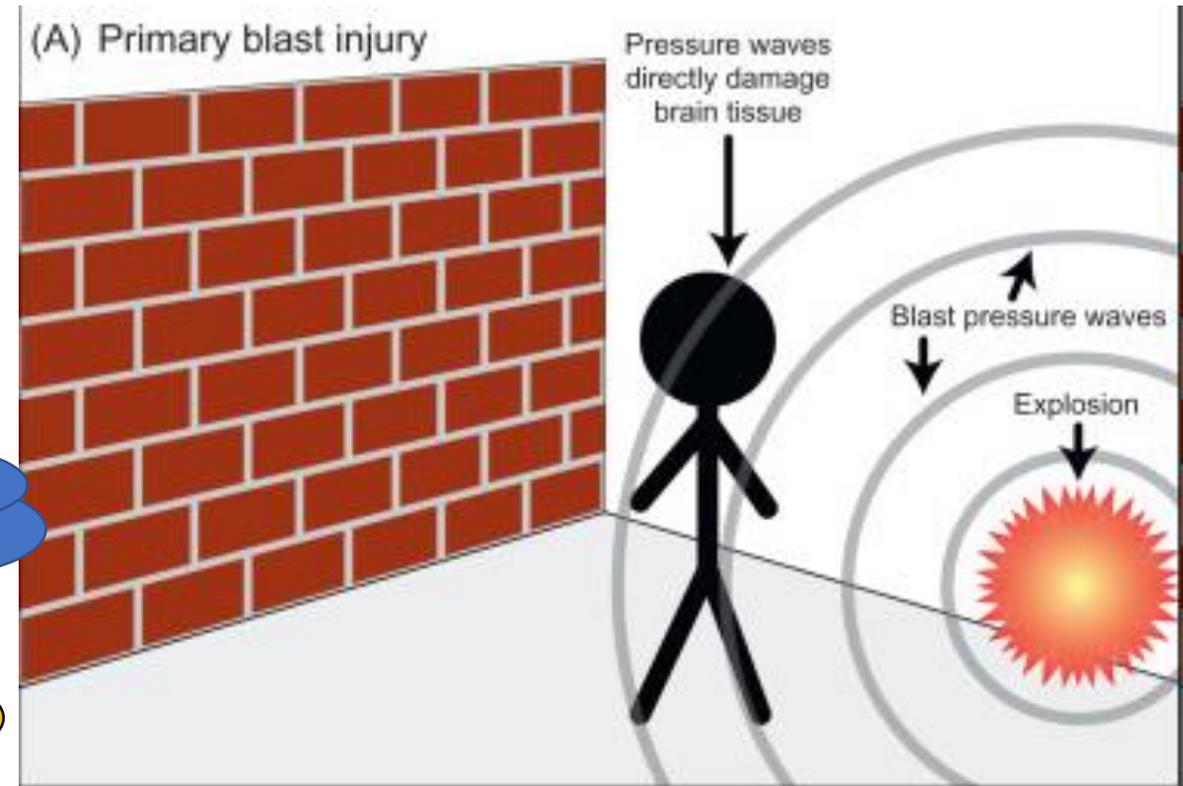
# A PRIMARY BLAST INJURIES

- A direct effect of blast wave overpressure on tissue
- Mostly (but not exclusively) affects air-filled structures such as the
  - ✓ Lungs
  - ✓ Ears
  - ✓ GI tract
- By the following mechanisms
  - ✓ spalling

The lung parenchyma to explode into the alveolar space like a geyser

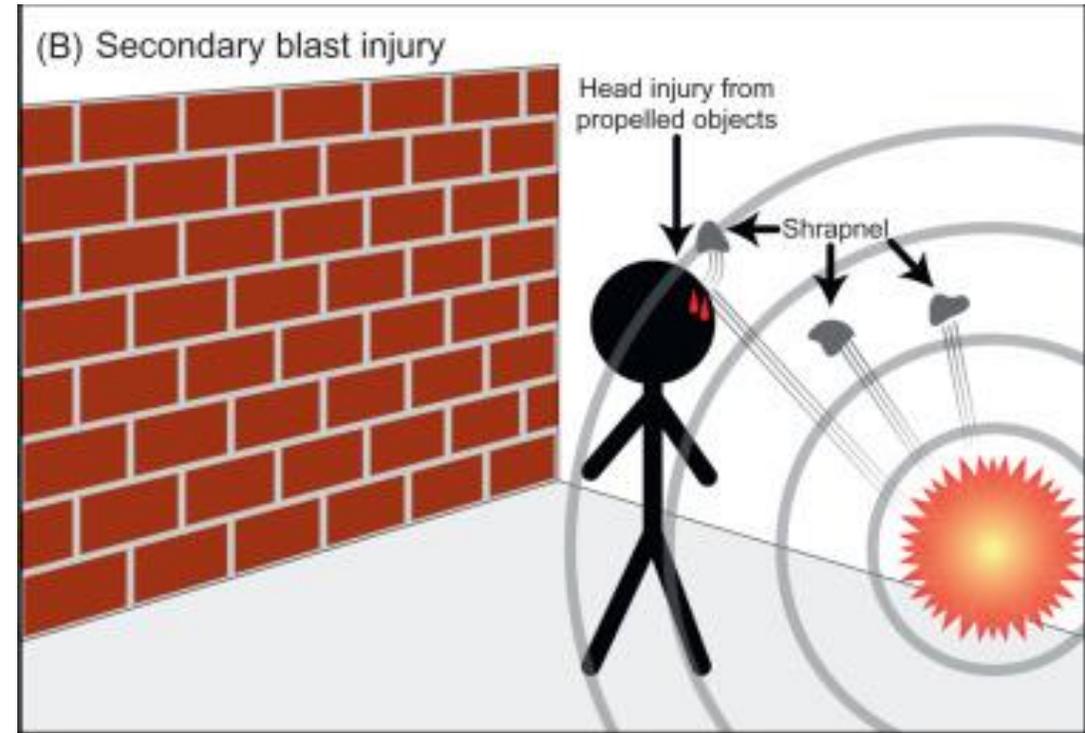
- ✓ Shearing
- Ruptured vascular and bronchial pedicles

- ✓ implosion
- Air embolism from the alveoli into the pulmonary vessels.



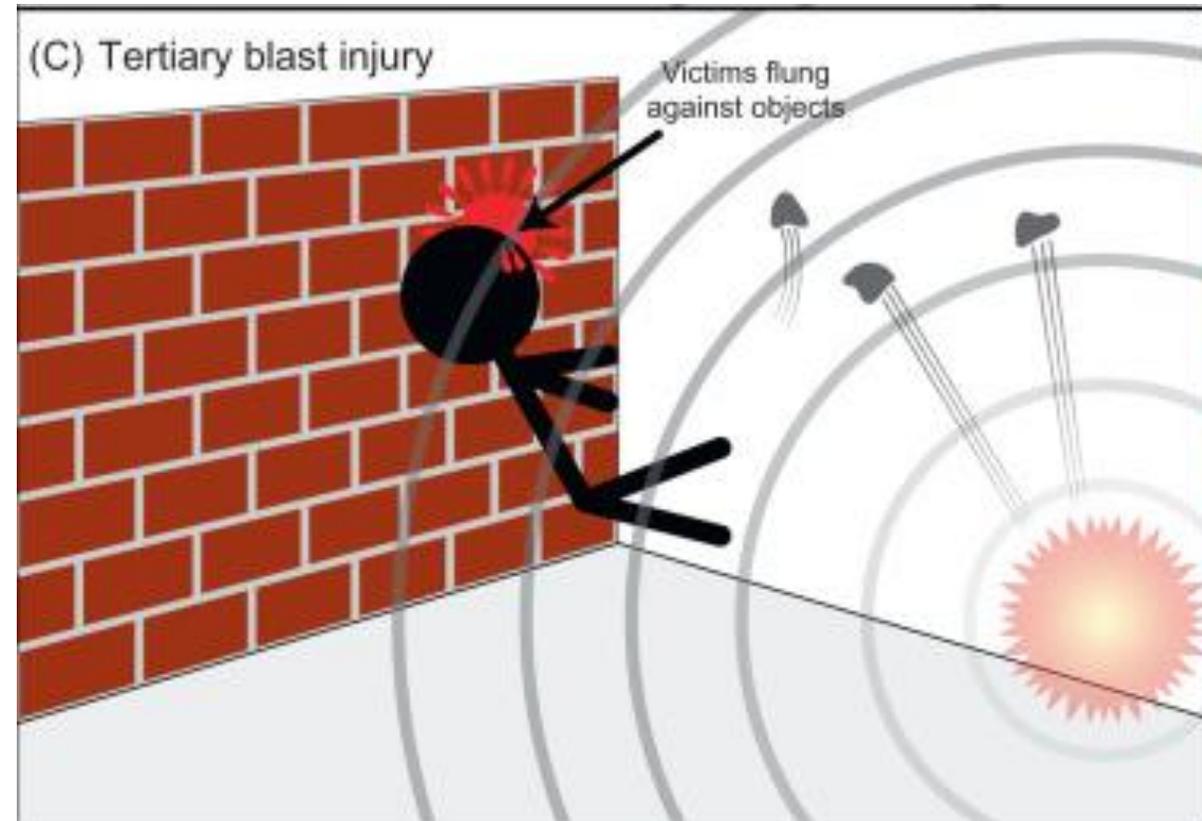
# A SECONDARY BLAST INJURIES

- Collateral damage from flying objects and shrapnel



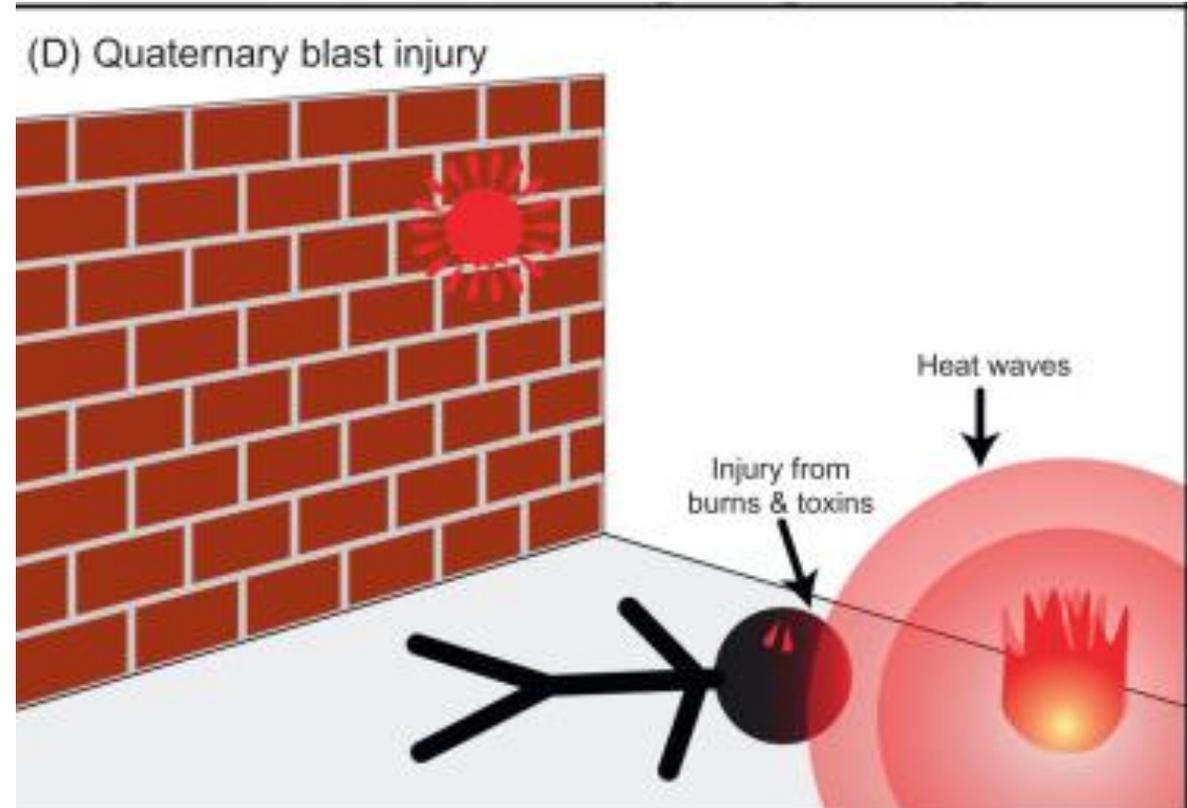
# A TERTIARY BLAST INJURIES

- Victim being propelled through the air and striking stationary objects.



# A QUATERNARY BLAST INJURIES

- Burns
- Smoke inhalation
- Chemical agent release



# FACTORS AFFECTING BLAST INJURY

- Distance of victim from explosion
- Enclosed versus open space
- Surrounding environment
- Quantity of explosive
- Type of explosive
- Embedded shrapnel

# CLINICAL FEATURES

- The nature of the injury may produce a multiplicity of external signs , making detection of important internal injuries challenging.

# CARDIOPULMONARY SYSTEM

- Pulmonary barotrauma is the most common fatal primary blast injury

# CARDIOPULMONARY SYSTEM

- Pulmonary contusion
- Pneumothorax
- Hemothorax
- Pneumomediastinum
- Subcutaneous emphysema

# CARDIOPULMONARY SYSTEM

- **Air embolism** is well-recognized consequence of blast lung injury
  - ✓ Cardiac dysfunction and immediate death although
  
  - ✓ It is usually difficult to diagnose specifically

# CARDIOPULMONARY SYSTEM

- **Hypoxia** is an almost universal finding
- **Monitoring of respiratory rate** and **room-air pulse oximetry**, as well as **serial chest radiographs**, may be needed

# CARDIOPULMONARY SYSTEM

- Fluid administration should ensure tissue perfusion without volume overload
- The decision to institute mechanical ventilation must be made careful

# CARDIOPULMONARY SYSTEM

- Keep **tidal volume to 6 to 7 mL/kg** ideal body weight to minimize **ventilator-induced lung barotrauma**.
- **Neuromuscular paralysis** and early institution of pressure-limited ventilation (plateau pressures)
- **Inverse inspiratory-to-expiratory ratio** ventilation may be useful
- **Permissive hypercapnia** is acceptable depending on cerebral perfusion pressure or increased intracranial pressure
- **Aggressive methods of oxygenation**, such as extracorporeal membrane oxygenation or intravascular oxygenation, may become necessary within hours of the injury.

# CARDIOPULMONARY SYSTEM

- In general, **asymptomatic patients** with **normal chest radiographs** and normal room-air pulse oximetry may be considered for discharge after **4 to 6 hours of observation** as long as there is no clinical deterioration.

# EARS

- The tympanic membrane ruptures at 1 to 8 psi of dynamic overpressure
- Dislodgement of ossicles may also occur

# EARS

- Patients with an **isolated tympanic membrane perforation** and no other immediately identified injuries should have **a chest radiograph ordered** but do not automatically require an extended period of observation

# EARS

- Intact tympanic membranes do not imply the absence of serious injury
- Clinical judgment is necessary, and limited observation is reasonable for patients with intact tympanic membranes.

# ABDOMEN

- Abdominal injuries from explosions may be occult
- incidence of 1.3% to 33%
- Terminal ileum and cecum were the most commonly injured areas

# ABDOMEN

- Serial clinical examinations, serial imaging as needed, and **24- to 48-hour** observation are indicated whenever the suspicion arises.

# BRAIN INJURY

- Shrapnel are low-velocity missiles, often producing small entry wounds in survivors
- **Small entry wounds may be missed** under the hair,
- Evidence for traumatic brain injury may initially be benign or masked by anesthesia as the patient undergoes treatment for other life-threatening injuries.
- Neuroimaging is an important early diagnostic tool

# VASCULAR INJURY

- Small entry wounds from shrapnel may mask severe vascular injuries
- Compartment syndrome may develop and is difficult to diagnose, especially in patients receiving anesthesia.
- Observe for delayed presentation of compartment syndrome, and measure compartment pressure if any signs or symptoms develop
- Early angiography and intervention are indicated if pulses are lost.

# EXTERNAL HEMORRHAGE

- Military experience has shown that hemorrhage is **the most common** cause of preventable death in penetrating trauma
- Whether venous or arterial, blood loss from multiple wounds (internal and external) may be sufficient to cause hypovolemic shock

# EXTERNAL HEMORRHAGE

- Quickly control external bleeding with **direct pressure**.
- Apply **tourniquets** whenever blood loss cannot be controlled with direct pressure or the resources required to maintain direct pressure are insufficient during either treatment or transportation.
- Tourniquets have been successfully used **for up to 6 hours** in battlefield situations.
- Angiographic vascular occlusion is an attractive treatment option if the time and staff are available.
- Victims of blast mass casualty incidents may require massive amounts of blood and blood products

# OCULAR INJURIES

- Eye injuries from a blast wave may cause shearing damage to the orbit
- Ocular injuries are from a combination of primary and secondary processes

# OCULAR INJURIES

- Ocular injuries include
  - ✓ lid or brow lacerations
  - ✓ Conjunctival lacerations
  - ✓ Open globe injuries
  - ✓ Orbital fractures
  - ✓ Retinal detachment
  - ✓ Retained intraocular foreign body
  - ✓ Lens dislocation
  - ✓ Vitreous hemorrhage

# OCULAR INJURIES

- Eye examination is needed for all moderately to severely injured blast victims
- A poor initial visual acuity **is not a guarantee** of a poor final result.

# DIAGNOSIS

- **Order** diagnostic imaging judiciously in a mass casualty incident.
- Visualization of a metallic object on a single-plane radiograph is often inadequate for thorough evaluation, but it can direct the treatment team on the need for urgent surgery or for additional imaging.
- **Use the FAST** examination liberally.
- Plain chest radiographs, ultrasonography, and diagnostic peritoneal lavage are the most rapid studies used to evaluate for life-threatening injuries.
- Order laboratory tests sparingly.

# TREATMENT

- When blast injuries occur, they tend to be **unexpected**, occur **outside of regular working hours**, and often produce **moderate to large numbers** of simultaneously arriving casualties.

# TREATMENT

- **Drills and checklists are critical** for successful implementation of rarely used protocols
- Checklists should be
  - ✓ Concise
  - ✓ Never more than one to two pages
  - ✓ Available in a location known to everyone
- Implement the hospital plan for management of mass casualty incidents

# TREATMENT

- Obtain details about the explosion from patients and rescue teams.
- **The nature and location** of the blast, including **size and type** of charge, location in **open or closed space**, **structural collapse**, associated **fire** or **smoke**, and **toxic agent** release, will be helpful in making informed clinical decisions, especially with regard to disposition of moderately to severely injured casualties.
- Patient **triage** will be needed when multiple patients arrive. Station an **experienced emergency physician** or **surgeon** at the ED entrance to triage

# Criteria for the Triage in Bomb Injuries

Severely Injured	Lightly Injured
Airway compromise	Minor wounds
Breathing difficulty	Burns, first or second degree
Hemodynamic instability	Isolated trauma to a limb
Altered level of consciousness	Anxiety states
Vascular trauma	Most walking patients
Extensive second- to third-degree burns	

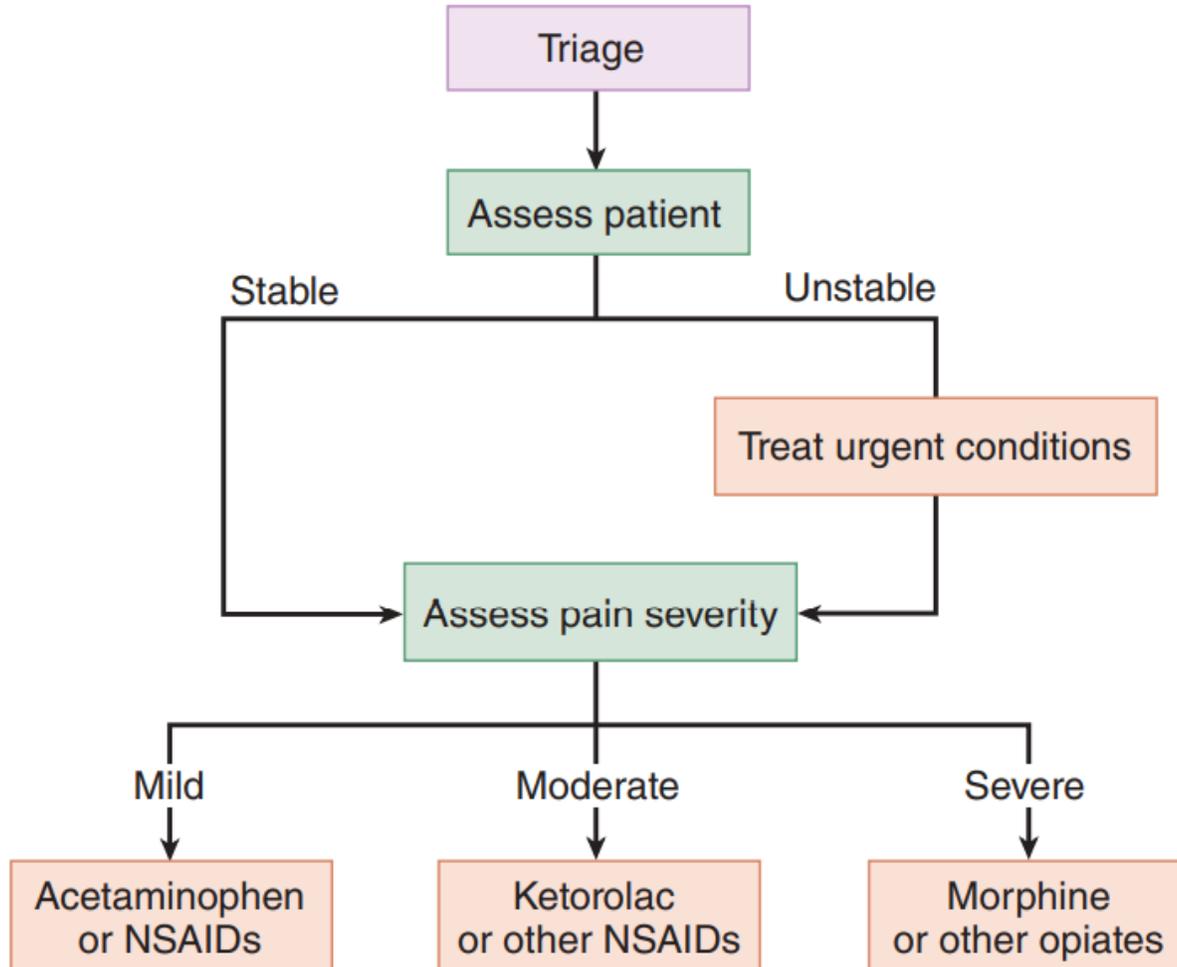
# TREATMENT

- Apply **the basic advanced trauma life support** principles
- Administer IV fluids and blood products judiciously.
- Preventing fluid overload is important for lung- and braininjured patients
- Activated factor VII administration or tranexamic acid may be considered in select cases of uncontrollable bleeding.
- Copiously irrigate and disinfect wounds urgently, but definitive debridement and closure may wait a few hours
- Temporary splinting, traction, and dressings are generally sufficient for initial management of musculoskeletal injuries.

# TREATMENT

- Consider **prophylactic antibiotics** for severely soiled wounds, penetrating abdominal and thoracic wounds, and open fractures, and in patients with diabetes or who are immunocompromised.
- Address pain management after life-threatening emergencies have been evaluated. Reserve opiates for patients with severe pain because opiate supplies may become limited

# PAIN MANAGEMENT



Algorithm for pain management in blast injury patients in the context of a multiple-casualty incident. NSAID = nonsteroidal anti-inflammatory drug

# TREATMENT

- Patients exposed to **open-space explosions** and who have **no significant injury, normal vital signs**, and an **unremarkable physical examination** generally can be discharged after a few hours of observation
- Asymptomatic patients may be discharged after 4 to 6 hours of observation.

# TREATMENT

Admit all patients with

- Significant burns
- Suspected air embolism
- Radiation or Chemical contamination
- Abnormal vital signs
- Abnormal lung examination findings
- Clinical or radiographic evidence of pulmonary contusion or pneumothorax
- Abdominal pain
- Vomiting
- Hypoxia
- Penetrating injuries to the thorax, abdomen, neck, or head

# TREATMENT

- Patients appropriate for discharge need to be given proper follow-up instructions.
- Secondary assessments of all casualties should be done before discharge
- Because symptoms of pulmonary contusion and intestinal hematoma may take 12 to 48 hours to develop, instruct all discharged patients to return for reevaluation if they develop breathing problems, abdominal pain, or vomiting.
- Provide relevant follow-up instructions in writing, including audiologic and ear, nose, and throat follow-up, wound care, immunization schedules, medications, psychological support, and social services.

# SPECIAL POPULATIONS

- PREGNANT WOMEN
- CHILDREN

# PREGNANT WOMEN

- Because the fetus is surrounded by amniotic fluid, direct injury to the fetus is uncommon.
- Injuries to the placenta, however, are more common.
- After life-threatening conditions have been stabilized, admit patients in the second or third trimester of pregnancy who have been exposed to blast injury to the labor and delivery area for continuous fetal monitoring and further testing and evaluation

# PREGNANT WOMEN

- Pelvic US, fetal nonstress test monitoring, and obstetrics consultation should always be obtained.
- Consider Rh immune globulin administration if the mother's blood type is Rh negative

# CHILDREN

- Children may suffer significant tertiary blast injury because their lighter bodies are more easily hurled by the blast wind
- Imaging, such as totalbody CT, may be difficult to perform in anxious and frightened child
- Children typically require sedation to facilitate imaging

# SPECIAL CONSIDERATIONS

- STAFF SAFETY
- FORENSIC ISSUES

# STAFF SAFETY

Issues that may affect staff safety include:

- (1) Possible infiltration of the ED by perpetrators intent on causing second explosions or attacks in the hospital
- (2) Unexploded explosives inadvertently brought into the ED
- (3) Transmissible disease in the setting of body fluid exposure or needle sticks during stressful, rapid work
- (4) Contamination of victims by chemical, radiologic, and biologic hazards, either accidental or intentionally caused by the perpetrators.

# FORENSIC ISSUES

**Prior coordination protocols**, such as

- Who and how many persons from these agencies are allowed in, when
- Into which parts of the ED, who controls them
- Who is empowered to limit their entry and work
- As a rule, however, although a terrorist event is a crime, forensics in the hospital are of minor relevance compared with the actual crime scene.
- Investigators may wish to interrogate victims with minor injuries regarding the event and obtain shrapnel or clothing from patients for forensic analysis.

THANK YOU FOR YOUR ATTENTION