BLAST INJURY

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Which of the following statements concerning blast lung injury are FALSE?

1) Blast lung injury should be suspected in victims with dyspnea and chest pain
2) May result in air emboli
3) CXR demonstrates “butterfly” pattern of infiltrates
4) All suspected victims of blast lung injury require immediate intubation with high PEEP settings
5) IV fluid should be minimized
BLAST INJURY

Dr. Charles Yowler does not have a significant financial relationship to report.
BLAST INJURY

Common in war

- WW I “shell shock”
- WW II air bombing campaigns
- IEDs

Terrorist Attacks

Industrial explosions
TERRORIST ATTACKS

Boston Marathon (4/15/2013)
• 3 deaths, 264 wounded

Oklahoma City (4/19/1995)
• 168 deaths, 680 wounded, damaged 324 buildings in a 16 block area

London Subway (7/7/2005)
• 52 died, 700 injured in 4 separate bombing incidents
NDUSTRIAL EXPLOSIONS

West Texas Fertilizer Plant (4/17/2013)
• 15 deaths, 60 injured

Texas City (4/16/1947)
• Largest non-nuclear explosion in history
• 581 deaths, 133 missing, 5,000 injured with 1,784 hospitalized
PATHOPHYSIOLOGY

Spallation – occurs when a pressure wave moves from a medium of higher density into a medium of lesser density

• Burst of water at the surface following an underwater explosion

Implosion – occurs when gases within tissues are compressed by the blast overpressure

Shearing – occurs at the interface of two tissues of differing density and thus different movement by the blast
PRIMARY BLAST INJURY (PBI)

Tissue injury due to transfer of energy from the blast wave

• uncommon in survivors since victims close enough to the blast to suffer PBI are usually killed by secondary and tertiary blast injuries
• may occur in military actions due to armor protection from secondary blast injury
SECONDARY BLAST INJURY

- Shrapnel
- Most common injury in survivors
- Penetrating injuries to brain, spine, trunk and extremities
- Injuries may be more severe than normally seen at civilian trauma centers
Injury secondary to displacement of the patient’s body by the blast wave

- Blunt injury to brain, spine, trunk and extremities
QUATENARY BLAST INJURY

- Crush
- Burn
- Inhalation Injury
- Radiological
- Psychological
Murrah Building - Injuries By Floor

- Fatality
- Admitted to Hospital
- Treated and Released
- Not Injured
- Private Physician
BLAST LUNG INJURY

Clinical Diagnosis

• Suspect in patients with hypoxia, dyspnea and chest pain

• May have hemoptysis, wheezing, hypotension
BLAST LUNG INJURY

- Alveolar injury to the blast wave
- May result in air emboli, hemothorax/pneumothorax, bronchopleural fistula
- CXR with butterfly pattern
- ABG, CT scan
BLAST LUNG INJURY
BLAST LUNG INJURY
Initial evaluation

- HFM for victims complaining of SOB, dyspnea, altered mental status or with documented hypoxia
- Do not intubate in field unless there is airway compromise or respiratory failure is imminent
- Hypotension may be secondary to tension pneumothorax
- Minimal IV fluids if not hypotensive
- Victims with no symptoms and normal CXR at 6 hours may be discharged
- However, delayed lung injury has been noted 24-48 hours after the blast injury
BLAST LUNG INJURY

Treatment

• HFM oxygen for hypoxia
• Chest tubes as indicated
• Intubation should only be utilized for airway compromise or impending respiratory failure
• Positive pressure ventilation increases the risk of death from air emboli
• ARDSnet guidelines with minimal use of PEEP
ABDOMINAL BLAST INJURY

Intestinal blast injury

- Bowel wall hemorrhage, immediate and delayed bowel perforation
- Mesenteric injuries with ischemic segments and delayed bowel perforations

Solid organs

- Lacerations
- Testicular rupture
ABDOMINAL BLAST INJURY

Initial evaluation

• Physical signs may be minimal in absence of immediate perforation
• FAST
• CT scan with contrast – poor sensitivity for intestinal injuries
• Serial abdominal exams and labs
• Immediate tachycardia is common. Beware, tachycardia that is progressive or does not respond to fluids and pain management.
Most susceptible organ to blast pressure wave
- TM perforation
- Disruption of ossicular chain

TM perforation is sensitive and should increase suspicion of other blast organ injuries.

However, it is not very specific and the great majority of patients with TM injury will have no other blast injury
EAR BLAST INJURY

• All victims of blast exposure should undergo screening audiograms which may be performed as an outpatient.

• Majority of TM perforations heal without operative intervention.

• Patients with TM perforation require long term follow up for cholesteatoma.
EXTREMITY INJURY

Traumatic amputation from PBI is rare

• In a series of 3,000 victims of blast injury, the amputation rate was 1.2%

Most extremity injuries are penetrating from second blast injury or blunt from tertiary/quaternary injury.

Pre-hospital tourniquets may be life saving
CRUSH SYNDROME

Tissue ischemia from compression prior to extrication and/or compartment syndrome following extrication

- Hypotension
- Acute kidney injury
- Hypocalcemia
- Hyperkalemia
- Metabolic acidosis
- Cardiac arrhythmia
CRUSH SYNDROME

Pre-hospital
• IV fluids (1.5 liters/hour)
• Consider tourniquet

Hospital
• Sodium bicarbonate 1 meq/kg push and consider drip
• IV fluids to maintain UO > 300 ml/hr
• Calcium gluconate as needed
Ocular injury in 28% of survivors of terrorist attacks

- Usually due to secondary blast effect
- PBI may result in hyphema, retinal detachment
EYE INJURY

Assume open globe injury in all patients presenting with ocular injuries

Fine-cut CT scans of orbits to locate metallic foreign bodies

MRI may be useful to locate nonmetallic foreign bodies
Classically described following secondary, tertiary and quaternary blast injury, TBI due to PBI has been recognized following recent conflicts. WWI “shell shock” felt to be a psychological disorder may have been due to PBI.
NEUROLOGIC INJURY

Iraq and Afghanistan – 40% of deaths due to IEDs

PATHOPHYSIOLOGY

- PBI
- Blast injury to thorax can lead to propagation of high-pressure waves that are transmitted to the brain by the systemic circulation
NEUROLOGIC INJURY

Body armor although protective against secondary blast injury has been shown to increase the effects of PBI to the thorax in animal models.

Body armor with shock absorbing properties are in development.
PET scans of veterans with suspected TBI and PTSD revealed abnormalities in brain stems of patients with TBI from blast injury versus PTSD. Many of those affected have no injuries that require immediate medical attention. High index of suspicion in survivors of events involving blasts.
BURN INJURY

Bomb-related burns typically <20% TBSA

Pre-hospital

- Stop the burning
- IV fluids (100 kg patient with 80% burn requires 2 liters of fluid in the first hour)
- Intubate for airway compromise or unconsciousness
- Minimal relationship between facial burns and airway compromise
INHALATION INJURY

Inhalation injury typically treated with low TV and high PEEP

This may lead to death in patients with PBI who may develop air emboli

Chemical inhalation must also be considered in industrial explosions
PEDIATRIC CONCERNS

Child more susceptible to PBI due to less truncal soft tissue to absorb blast wave and increased compliance of ribs

Will maintain BP despite significant hemorrhage

More susceptible to tertiary injury due to decreased mass
PEDIATRIC CONCERNS

Consider tension pneumothorax in any hypotensive, hypoxic child

Increased incidence of solid organ injury due to compliance of ribs

Increased incidence of high cervical fractures

SCIWORA
MASS CASUALTY

• Civilian blast injury involves a mass casualty event
• Triage at scene – avoid overwhelming hospitals with early transfer of minimally injured
• Hospitals must have areas where minimally injured can be screened for delayed treatment
HARTFORD CONSENSUS

• Conference met in response to mass shooting events in US
• Traditional approach to criminal/terrorist mass casualty events was to keep all medical first responders from entering the area until law enforcement had cleared the area
• This led to delays of several hours for any victims to receive medical attention
Law enforcement had no responsibility to treat the wounded or clear the scene – they also had no training in this area.

In contrast, the military had recognized the importance of early “buddy care” and every soldier was trained in basic first aid including control of exsanguination with direct pressure or tourniquets.
HARTFORD CONSENSUS

THREAT

- Threat suppression
- Hemorrhage control
- Rapid extrication
- Assessment by medical providers
- Transport to definitive care
SUMMARY

• Majority of survivors with penetrating and blunt injuries with no PBI
• Significant PBI usually involves lung and abdomen
• Minimize airway pressures in patients with suspected blast lung injury
• Law enforcement organizations need training in control of hemorrhage and medical evacuation
SUMMARY

• Terrorists bombings can overwhelm urban trauma centers – hospital response of “transfer to trauma center” is not feasible in most urban areas

• Industrial explosions typically occur in rural areas with limited medical facilities

• Military bases also typically in rural areas and military hospital is small
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