Blast Injuries

2009 2nd Quarter CE Packet
04/15/2009-05/29/2009

Background
Explosions have the capability to cause multisystem, life-threatening injuries in single or multiple victims simultaneously. These types of events present complex triage, diagnostic, and management challenges for the health care provider. Explosions can produce classic injury patterns from blunt and penetrating mechanisms to several organ systems, but they can also result in unique injury patterns to specific organs including the lungs and the central nervous system. Understanding these crucial differences is critical to managing these situations.

The extent and pattern of injuries produced by an explosion are a direct result of several factors including the amount and composition of the explosive material (eg, the presence of shrapnel or loose material that can be propelled, radiological or biological contamination), the surrounding environment (eg, the presence of intervening protective barriers), the distance between the victim and the blast, the delivery method if a bomb is involved, and any other environmental hazards. No two events are identical, and the spectrum and extent of injuries produced varies widely.

Between 1991 and 2000, 93 terrorist attacks worldwide produced more than 30 casualties, with 85 of these incidents involving explosions. The 2005 London subway bombings, the 1995 bombing of the Murrah Federal Building in Oklahoma City, and the catastrophic explosions of aircraft into 3 buildings on September 11, 2001 in New York City and Washington DC reminded health care workers of the magnitude of injuries and death that can result from a blast mechanism. Internationally, explosive devices directed against both civilian and military targets are frequently used in war or acts of terrorism. Although the United States has been spared the majority of these events, the potential exists for use of explosive weapons in the United States in the future.

As the risk of terrorist bombings in the United States increases, emergency physicians and Emergency Medical Services (EMS) personnel should be especially concerned about radiation and/or chemical contamination of explosion victims. Careful observation for signs and symptoms of exposure to poisonous chemicals, screening for radiation contamination, and decontamination of patients as needed are important steps in the management of victims of nonaccidental explosions. In addition to deliberately set explosions, incidents also occur as a result of industrial accidents (eg, factory and mining operations, fuel transportation and storage, grain elevator explosions).
In many parts of the world, undetonated military incendiary devices such as land mines and hand grenades contaminate the sites of abandoned battlefields. Such devices cause significant numbers of civilian casualties years and even decades after local hostilities cease. During wartime, injuries arising from explosions frequently outnumber those from gunshots with many innocent civilians becoming victims.

Much of the challenge facing the care providers is the potential for the sudden creation of large numbers of patients who require extensive medical resources. This scenario can overwhelm local EMS and hospital resources. Emergency physicians must remain attentive to the possibility and consequences of blast injuries.

**Pathophysiology**

Blast injuries traditionally are divided into 4 categories: primary, secondary, tertiary, and quaternary (or miscellaneous) injuries. A patient may be injured by more than one of these mechanisms.

- A primary blast injury is caused solely by the direct effect of blast overpressure on tissue. Air is easily compressible, unlike water. As a result, a primary blast injury almost always affects air-filled structures such as the lung, ear, and gastrointestinal (GI) tract.
- A secondary blast injury is caused by flying objects that strike people.
- A tertiary blast injury is a feature of high-energy explosions. This type of injury occurs when people fly through the air and strike other objects.
- Miscellaneous blast-related injuries encompass all other injuries caused by explosions, such as burns, crush injuries, and toxic inhalations. For example, the crash of two jet airplanes into the World Trade Center only created a relatively low-order pressure wave, but the resulting fire and building collapse killed thousands.

**Mortality/Morbidity**

- Mortality rates vary widely between incidents. An analysis of 29 large terrorist bombing events between 1966 and 2002 showed 8,364 casualties, including 903 immediate deaths and 7,461 immediately surviving injured. Immediate death/injury rates were higher for bombins involving structural collapse (25%) than for confined space (8%) and open-air detonations (4%).
- Unique patterns of injury are found in all bombing types. Injury is caused both by direct blast overpressure (primary blast injury) and by a variety of associated factors. Enclosed-space explosions, including those occurring in busses, and in-water explosions produce more primary blast injury. Explosions leading to structure collapse produce more orthopedic injuries. Land mine injuries are associated with a high risk of below- and above-the-knee amputations. Fireworks-related injuries prompt an estimated 10,000-12,000 ED visits in the United States annually, with 20-25% involving either the eye or hand.
- Presence of tympanic membrane (TM) rupture indicates that a high-pressure wave (at least 40 kilopascal [kPa], 6 psi) was present and may correlate with more dangerous organ injury. Theoretically, at an overpressure of 100 kPa (15 psi), the threshold for lung injury, TM routinely ruptures; however, a recent Israeli case series of 640 civilian victims of terrorist bombings contradicts traditional beliefs about a clear correlation between the presence of TM injury and coincidence organ damage. Of 137 patients initially diagnosed as having isolated eardrum perforation who were well enough to be discharged, none later developed manifestations of pulmonary or intestinal blast injury. Furthermore, 18 patients with pulmonary blast injuries had no eardrum perforation.
History

- If possible, determine what material caused the explosion.
  - High-order explosives (HEs) undergo detonation, an almost instantaneous transformation of the original explosive material into gases occupying the same volume of space under extremely high pressure. These high-pressure gases rapidly expand, compress the surrounding medium, and produce a defining supersonic, over pressurization blast wave. Examples of HEs include materials such as TNT, ammonium nitrate fuel oil, dynamite, and C-4 "plastic" explosives. In general, only HE explosions produce severe primary blast injury.
  - Low-order explosives (LEs) are composed of propellants, such as black powder, and pyrotechnics, such as fireworks. LEs undergo deflagration rather than detonation and release energy relatively slowly compared with HEs. This results in a subsonic explosion lacking the over pressurization blast wave that characterizes HEs. Although LE explosions can be deadly, LE explosions very uncommonly cause the pulmonary and central nervous system injuries unique to primary blast injury.
- If possible, determine the patient's location relative to the center of the explosion.
  - An explosion that occurs in an enclosed space (including a building, a mine, or a relatively lightly constructed enclosed space such as a bus) or in water tends to cause more serious injury.
  - Intensity of an explosion pressure wave declines with the cubed root of the distance from the explosion. A person 3 m (10 ft) from an explosion experiences 9 times more overpressure than a person 6 m (20 ft) away. Proximity of the person to the explosion is an important factor in a primary blast injury.
  - Blast waves are reflected by solid surfaces; thus, a person standing next to a wall may suffer increased primary blast injury.
- Because explosions often cause multiple casualties, anticipate activating the hospital or regional disaster plan.
- Another ominous consideration is the tactic of setting dual explosions. The initial explosion is intended to injure civilians and to attract law enforcement and rescue personnel, followed by a delayed explosion designed to injure rescuers. Hospital disaster plans should include tight security at all hospital entrances in the event of a terrorist explosion in the community. All hospital personnel should be alert for unattended packages.
  - In addition to protecting hospital patients and staff, sealing entrances helps control the chaotic flow of patients and visitors.
  - Industrial accidents and terrorist explosions may be associated with the release of toxic and/or radioactive materials. The Federal Bureau of Investigation (FBI) is particularly concerned about the possibility that a terrorist could attach a radioactive substance (eg, a radiopharmaceutical or part of an old radiography machine) to a conventional explosive device, causing radiation contamination of the scene and casualties. In the 1993 attack on the World Trade Center, terrorists attached cyanide to a bomb placed in the underground parking garage. Fortunately, in that incident the cyanide was destroyed by the combustion. Physicians and EMS personnel must diligently search for evidence of radiation and/or chemical contamination in persons with blast injuries.
  - Question plant managers, fire department officials, EMS personnel, and law enforcement personnel about these possibilities.
  - EMS agencies should check for radiation contamination at the scene of a deliberately caused explosion. In addition, hospital personnel should screen persons who have been exposed to deliberate explosions for radioactivity with a Geiger counter or similar radiation dosimeter. Each hospital has a radiation safety officer (usually a radiology technician) who can assist with this task.
Physical

- Examine lungs for evidence of pulmonary contusion and pneumothorax.
  - Assume that a patient's wheezing associated with a blast injury is from pulmonary contusion.
  - Other causes of wheezing in this setting may include inhalation of irritant gases or dusts, pulmonary edema from myocardial contusion, and adult respiratory distress syndrome (ARDS).

- Abdominal injuries from explosions may be occult, and serial examinations are often required.
  - A recent large Israeli case series found that abdominal injuries occurred only as a result of massive trauma. This finding may be the result of selection bias, as all the explosions in their series occurred in open air. Air is a poor conductor of blast-wave energy, thus those who were subjected to enough energy to damage abdominal organs probably were situated near the explosive devices.
  - Other authors have reported occult injuries to both solid and hollow abdominal organs in people injured by closed-space explosions and blast injuries occurring in water.

Causes

- Primary blast injury
  - Primary blast injury (PBI) is organ and tissue damage caused solely by the blast wave associated with HEs.
    - The leading edge of a blast wave is called the blast front. When a blast front reaches a victim, it causes an enormous, almost instantaneous rise in ambient pressure. For example, C4 explosions can create initial pressures of over 4 million pounds per square inch (30GPa).
    - Because explosive gases continue to expand from their point of origin, a longer negative underpressure (relative vacuum) follows the peak positive overpressure. Both the positive overpressure and the negative underpressure are capable of causing significant PBI.
  - Since air is easily compressible by pressure while water is not, gas-containing organs, especially the lungs, bowel, and middle ear, are most susceptible to PBI.
  - Pulmonary barotrauma is the most common fatal primary blast injury. This includes pulmonary contusion, systemic air embolism, and free radical–associated injuries such as thrombosis, lipoxygenation, and disseminated intravascular coagulation (DIC). ARDS may be a result of direct lung injury or of shock from other body injuries.
  - Thoracic PBI produces a unique cardiovascular response, observed nowhere else in medicine, that which is sufficient to cause death in the absence of any demonstrable physical injury. The immediate cardiovascular response to pulmonary blast injury is a decrease in heart rate, stroke volume, and cardiac index. The normal reflex increase in systemic vascular resistance does not occur, so blood pressure falls. This effect occurs within seconds. If this response is not fatal, recovery usually occurs within 15 minutes to 3 hours. However, even nonlethal PBI can impair pulmonary performance for hours to days.
  - Acute gas embolism (AGE), a form of pulmonary barotrauma, requires special attention. Air emboli most commonly occlude blood vessels in the brain or spinal cord. Resulting neurologic symptoms must be differentiated from the direct effect of trauma.
  - Intestinal barotrauma is more common with underwater than air blast injuries. Although the colon usually is affected most, any portion of the GI tract may be injured.
The ear is the organ most susceptible to primary blast injury. Acoustic barotrauma commonly consists of TM rupture. Hemotympanum without perforation also has been reported. Ossicle fracture or dislocation may occur with very high-energy explosions.

- **Secondary blast injury**
  - Secondary blast injuries (SBIs) are caused by flying objects striking individuals.
  - This mechanism is responsible for the majority of casualties in many explosions. Penetrating thoracic trauma, including lacerations of the heart and great vessels, is a common cause of death in the setting of SBIs. For example, the glass facade of the Alfred P. Murrah Federal Building in Oklahoma City shattered into thousands of heavy glass chunks that were propelled through occupied areas of the building with devastating results. During the 1998 terrorist bombing of the US Embassy in Nairobi, flying glass wounded people up to 2 km away.
  - Military explosive casings (e.g., hand grenades) are specifically designed to fragment and to maximize damage from flying debris (shrapnel).
  - Civilian terrorist bombers (e.g., Olympic Park in Atlanta) often deliberately place screws or other small metal objects around their weapons to increase secondary blast injuries.

- **Tertiary blast injury**
  - Tertiary blast injuries are caused by individuals flying through the air and striking other objects, generally from high-energy explosions.
  - Unless the explosion is of extremely high energy or focused in some way (e.g., through a door or hatch), a person with tertiary blast injury usually is very close to the explosion source.
  - Together with SBIs, this category accounted for most of the pediatric casualties in the Oklahoma City bombing. A high incidence of skull fractures (including 17 children with open brain injuries) and long-bone injuries including traumatic amputations occurred.

- **Miscellaneous blast-related injuries**, sometimes termed quaternary blast injury, include burns (chemical or thermal); injury from falling objects; crush injuries from collapsed structures and displaced heavy objects; falls resulting from the explosion; and toxic dust, gas, or radiation exposure.

### Prehospital Care

EMS personnel should attempt to determine and report any information regarding the nature and size of the explosion; the time of occurrence; the proximity of the victim to the epicenter of the blast; victim displacement by the blast wind if any; the presence of secondary fires, smoke, dust, or chemical or radioactive contamination; and history of entrapment in collapsed structures. EMS personnel are responsible for activating appropriate disaster and/or hazardous material responses as early as possible.

- Analysis of blast incidents indicates that "upside-down" triage is common; less injured patients typically arrive at the hospital, via ambulance or private vehicle, before the most severely injured victims.
- Screening for radioactive contamination with a hand-held Geiger counter is a prudent precaution for any explosion that may involve radioactive material, including any explosion that may have been deliberately set. If radioactive material is detected, decontamination of personnel and equipment as well as notification of the receiving hospital is required. The Radiation Emergency Action Center and Training Site (REAC/TS) provides advice and assistance; their 24-hour emergency telephone number is - (865) 576-1005.
- Significant extremity trauma and associated death from exsanguination is a major cause of preventable death. EMS personnel should rapidly identify patients with life-threatening external hemorrhage and control bleeding. Early use of tourniquets may be life-saving, especially in the setting of multiple seriously injured casualties.
- High-flow oxygen should be administered to all patients with respiratory distress, abnormal findings on auscultation, and evidence of significant thoracic trauma.
- EMS personnel should avoid administration of large quantities of intravenous fluid in patients with a high suspicion of ongoing internal hemorrhage. Judicious fluid boluses may be required if patients
exhibit signs and symptoms of inadequate perfusion, such as deteriorating mental status, in this setting.

- EMS personnel should initiate measures to reduce heat loss and prevent hypothermia in the trauma patient since this condition is associated with increased mortality.
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Name: ______________________  Department: ____________________

1. What are four types of blast injuries?
   A. Primary, Secondary, Tertiary, Quaternary.
   B. First, Second, Tertiary, Final.
   C. Big Blast, Secondary, First Responder Blast, Final.
   D. Laceration, Decapitation, Broken Bones, Burns.

2. What is the most common injury in primary blast victims?
   A. Thermal Burns.
   B. Injury to Air Filled Sacs in the Body.
   C. Impaled Objects.
   D. Toxic Inhalations.

3. Name four types of High Order Explosives (HE’s.)
   1. 
   2. 
   3. 
   4. 

4. What blast injury victim would most likely present with shrapnel wounds?
   A. Primary
   B. Secondary
   C. Tertiary
   D. Quaternary

5. What is the MOI of a Tertiary Blast Injury?
   A. The initial blast that injures the air filled structures in the body.
   B. Toxic gas inhalation.
   C. Flying object that strike people.
   D. High-energy explosions that throw victims through the air.
6. What’s the most important scene consideration when dealing with potential injuries from an explosion?
   A. Diffusing the bomb.
   B. Scene Safety.
   C. Treating the patients.
   D. Apprehending terrorists.

7. What are three signs or symptoms of a pneumothorax due to a primary blast injury?
   A. Difficulty breathing, Tracheal deviation, Decreased lung sounds on affected side.
   B. Bruising on the chest, Burns on the chest, Difficulty breathing.
   C. Chest pain, Wheezing, Head ache.
   D. Unresponsive, Clear lung sounds, Midline trachea.

8. Why are Acute Gas Embolisms life threatening?

9. What is upside down triage?
   A. Placing triage tag on victim upside down.
   B. Less injured victims self rescue and arrive at ED prior to other victims.
   C. Severely injured victims go to hospital first.
   D. Victims are treated “first come-first serve.”

10. O2 should be administered to all patients with difficulty breathing even if they have an allergy to it?
   
   True.  False.

CE packets are to be turned in by 4pm on 5/29/2009 to the South Region EMS Office at AMHB. If you have any questions please contact Dustin Ellis – dustin.ellis@aurora.org.
Once on main screen, choose "Course Search"

Choose "By Course ID"
Enter course number 1015602 for the WMD Course and click "Search"
WI-Train Directions for Weapons of Mass Destruction Training

**Course Details**

**Weapons of Mass Destruction**

- **Course ID:** 1015602
- **Format:** Web-based Training - Self-study (Online)
- **Clinical / Non-Clinical:** Non Clinical
- **Course Number:** DL-06-800
- **Credit Type(s):** 1.5 of Emergency Medical Technician
- **Certificate:** TRAIN Certificate of Attendance

**Course Description:**

This course provides a narrated powerpoint lecture to view and a quiz to complete regarding weapons of mass destruction training as outlined in WI Stat 255.15 (6) 2 as required for licensure of emergency medical technicians. This course covers information regarding recognition and awareness of weapons of mass destruction.

If you are experiencing technical difficulties, please check your computer capability: click the Help tab in the TRAIN navigation bar, then click “Test Your Environment” on the left-hand menu.

**Select Credit Type:**

- Select
- Emergency Medical Technician

**Answer “yes” or “no” to this question.**

**Clicking the “Launch” button will complete your registration and take you to program link.**
Scroll towards bottom

Click here to start video presentation
You may start and stop the presentation and return at another time. When you have completed the program you can close the window and you should still be in WI-Train. Otherwise navigate to the home page and sign in.
To complete the course and take final exam click "M" icon.

To resume video click on "Weapons of Mass Destruction".

If you have completed the course and wish to take the exam click the "Completed" button.
Warning will show - click "OK"

Click assessment to start quiz
**WI-Train Directions for Weapons of Mass Destruction Training**

**Weapons Of Mass Destruction Post Test**

*Time limit: 00:20:00 (20 minutes)*

Click 'Start Assessment' button to start the assessment.

![Click "Start Assessment" to take exam](image)

**Weapons Of Mass Destruction Post Test - Question 1 of 10.**

The following statement is true: [ ]

![Exam will begin - select best answer and click "next" to go to the next question](image)
When completed you will receive your score. 70% is the minimum passing score.

After exam you will receive the above page showing completion.
Once you have completed the course click "Certificates".

Click on "Certificate of Attendance".
Once completed print your certificate and submit a copy with your application for licensure or send as requested by our office. Congratulations!