Blast Injuries

Description/Etiology

Blasts, or explosions, cause devastating injuries by a variety of mechanisms. At detonation, a blast produces an outward, high-pressure shock wave that travels radially at supersonic speed from the center of the blast, with a leading edge that immediately increases air pressure. This is followed by a powerful reverse wind, pulling back in the direction of the blast, leading to underpressurization. The shock wave causes progressively less damage as it moves away from the origin of the blast. Generally, all persons in the immediate vicinity (e.g., within 5 feet [1.5 m]) of a blast that is 200–250 psi (13.6–17.0 atmospheres) will be killed. Blasts cause more injuries if they occur in confined spaces (e.g., in buildings, mines, large vehicles) or if the shock wave moves through narrow streets.

Over 100,000 military service members suffer from traumatic brain injuries caused by explosive devices, which is a result of being exposed to blast overpressure from firing large-caliber weapons (e.g., Carl Gustaf recoilless rifle). Service members exposed to these explosives or high-caliber weapons (even during training) can develop various cognitive deficits, especially those involving memory loss. A crucial mechanism for brain injuries are primary blast pressure waves caused when firing these large-caliber weapons. Currently, the United States Army does not provide protection against blast injuries caused by explosives.

Effects of blasts on the human body are divided into four categories, or stages:

› Primary blast injuries (PBIs) result from the direct pressure effects from barotrauma (i.e., pressure changes; overpressurization and underpressurization), primarily in gas-containing visceral organs (e.g., ears, lungs, and intestines)
› Secondary blast injuries (SBIs) are penetrating wounds from primary (i.e., part of the weapon device) and secondary (i.e., resulting from the explosion) fragments that produce multiple high-energy penetrating injuries
› Tertiary blast injuries (TBIs) are the result of indirect (i.e., not related to barotrauma or to primary/secondary blast fragments) crush, penetrating, and blunt trauma, including fractures, traumatic amputations, traumatic brain injury from structural collapse (e.g., a falling building), and being thrown or blown by the blast wind
› Quaternary (also called miscellaneous) blast injuries (QBI) include burns (e.g., from thermal effects of the explosion or secondary fires), asphyxia, and toxic inhalant exposure

Treatment is specific to the injury but generally involves resuscitation, management of hemorrhage, pain control, intensive monitoring, surgical intervention, and providing patient/family emotional support and education. There are no recommended neuroprotective drugs that can effectively help prevent traumatic brain injuries caused by explosions and no generalized treatments because each case involving blast injuries is unique.

Facts and Figures

The middle ear is the most sensitive organ to PBI; up to 32% of patients injured in explosions have ruptured tympanic membranes, the presence of which indicates a pressure wave of at least 6 psi. Ocular injuries affect up to 28% of victims of blast injuries and 1–3% of blast victims experience traumatic amputation. Crush injuries that occur secondary to blasts most often involve the lower extremities (74%), upper extremities (10%), and trunk (9%). Each year in the US, 10,000–12,000 persons are treated in the emergency department for fireworks-related injuries; 20–25% of these cases involve injury to the eye.
or hand. During the period 2001–2011, 501 male US service members deployed to Iraq and Afghanistan sustained genitourinary injuries, 89% of which were the result of improvised explosive devices (IEDs); 36% of these patients also had limb amputations and 17% had bone fractures (Banti et al. 2016).

**Risk Factors**

Military personnel, nonmilitary inhabitants of war zones, and persons working in plants with large quantities of volatile substances are at risk for blast injury. Terrorist activity has increased the risk for blast injury in major urban areas (e.g., prominent buildings, public gathering places, major cities). Suicide attacks usually result in severe and lethal injuries caused by the devastating power of a blast in reduced spaces and highly populated areas.

**Signs and Symptoms/Clinical Presentation**

PBI can involve rupture of the eye or the tympanum manifested by deafness (usually temporary), tinnitus, vertigo, facial fractures, pulmonary contusion, hemothysis, hemothorax, pneumothorax, abdominal hemorrhage and perforation, traumatic brain injury (with or without physical signs of head injury), acute gas embolism, and loss of consciousness can occur. Patients with SBI can have fragment wounds, fractures, traumatic amputations, and soft tissue injuries. Compartment syndrome (i.e., tissue pressure elevation in a closed fascial compartment that disrupts blood flow and impairs nerve function) and crush syndrome (i.e., tissue damage and systemic dysfunction resulting from prolonged traumatic muscle compression) are often reported in patients with TBI; other manifestations of TBI can include fracture, traumatic amputations, and open or closed brain injury. Patients with QBIs can experience burns, toxic inhalation, asphyxiation, dust inhalation, crush injuries, angina, hypertension, and hyperglycemia. Injured individuals with preexisting medical conditions (e.g., hypertension, cardiovascular disease) can experience exacerbation of chronic symptoms. Posttraumatic stress disorder (PTSD) and subjective sleep disturbances (SSD) are increasingly being reported as complications of nonpenetrating battlefield blast injuries.

**Assessment**

- **Laboratory Tests**
  - CBC might show anemia and other abnormal values, indicating hemorrhage
  - Serum electrolyte levels can be abnormal, indicating respiratory dysfunction or massive tissue necrosis (i.e., tissue necrosis and dissolution)
  - Blood typing and cross-matching is commonly performed in preparation for potential transfusion, and many injury-specific tests can be ordered

- **Other Diagnostic Tests/Studies**
  - X-ray can be ordered to assess wound location, extent of injury, and position of metallic fragments; patients with ruptured tympanum should have a chest X-ray to assess for lung damage
  - CT scan and MRI images can be performed to assess the extent of wounds
    - In a study of 834 US military service members with a history of blast-induced traumatic brain injury, structural MRI identified a high incidence of white matter T2-weighted hyperintense areas and pituitary abnormalities (Riedy et al., 2016)
  - Other imaging tests (e.g., digital subtraction angiography [DSA], multidetector CT angiography) can be ordered, depending on the injury type (e.g., vascular trauma)

**Treatment Goals**

- **Promote Patient Resuscitation and Reduce Risk of Injury-Related Complications**
  - Assist with cardiac/respiratory resuscitation efforts and hemorrhage management; maintain patient safety (e.g., airway, circulation, and prevention of injury)
  - Continually monitor vital signs, assess all physiologic systems, and review laboratory/other diagnostic test results; immediately report abnormalities and provide prescribed treatment
    - Prevent blood loss and infuse IV fluids to maintain systolic blood pressure above 100 mm Hg; maintain renal perfusion but avoid fluid overload
    - Maintain oxygen and mechanical ventilation, if ordered
  - Assess frequently for adequate pain management; provide analgesic medication, as ordered
  - Administer/assist with prescribed treatment that is specific to injury; promote effective communication of patient status in all specialty clinicians involved
Follow facility pre- and postsurgical protocols if patient becomes a candidate for surgery (e.g., repair of pneumothorax or fracture, limb amputation); reinforce pre- and postsurgical education and verify completion of facility informed consent documents.

Give tetanus prophylaxis, as ordered, and monitor for complications (e.g., infection); provide prescribed antibiotics, corticosteroids, and/or other treatment.

Because victims of blast injuries can be exposed to blood borne pathogens via body fluids and other biologic material (e.g., bone fragments), contaminated weapon fragments, and other debris, the US Centers for Disease Control and Prevention recommends administration of the hepatitis B vaccine to victims of blast injuries who have penetrating injuries, nonintact skin, or mucous membrane exposures unless the patient is known to have received the full vaccination series or to have a contraindication to receiving the immunization. HIV post-exposure prophylaxis should only be considered if exposure is to a known or highly likely source of HIV infection and the blast victim has penetrating injuries, nonintact skin, or mucous membrane exposures.

Encourage/assist with optimum nutrition and hygiene; assist with ADLs, as appropriate.

Following the acute phase, request referral to physical and/or occupational therapy.

Promote Emotional Well-Being and Educate

Assess patient’s anxiety level and coping ability; provide emotional support and evaluate for compromise in ability to communicate caused by injury (e.g., hearing loss). Identify alternate means of communication (e.g., writing, nodding, tapping finger in answer to questions), as appropriate.

Assist with contacting family members, as appropriate.

Educate and encourage discussion about blast injury, resuscitation efforts, potential complications, treatment risks and benefits, associated psychological effects of traumatic injury (e.g., PTSD), and individualized prognosis; request clinician referral, if appropriate, to a mental health clinician for counseling on coping strategies.

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Social worker for identification of local resources for support groups, transportation, outpatient treatment, in-home services, and online sources of education and support.

Food for Thought

Compared with military surgeons, who have traditionally been responsible for managing blast injuries occurring in war, few civilian surgeons are familiar with the effects of blast injuries; as the number of blast injuries caused by terrorist activity continues to increase worldwide, nonmilitary healthcare clinicians are being increasingly exposed to these injuries.

Hearing protection devices effectively reduce the risk of tympanic injuries and hearing loss in individuals at high risk for blast injuries (e.g., military personnel deployed in combat areas).

Using physical experiments and computer modelling, researchers concluded that explosive-induced blast injuries to the brain can be reduced as much as 80% by adding molecular face shields to US Army helmets (Fish et al., 2018)

Age-specific research for blast injuries in children is lacking in the literature, specifically regarding long-term effects and recovery of children who have experienced blast injuries. Additionally, there is little evidence outlining appropriate management of psychologic and physical care of pediatric patients with blast injuries and there are few registries for pediatric patients with blast injuries (Hargrave, 2017).

Researchers in a randomized controlled trial evaluated interventions for primary blast injuries in veterans and found that in 99 participants, a personal frequency modulation system was the most effective audiologic rehabilitative intervention for veterans who reported difficulty in hearing; other interventions included compensatory communication strategies, an auditory training program, and a combination of a personal frequency modulation system and compensatory communication strategies (Saunders et al., 2018).

Red Flags

Patients with lung injury who develop immediate pulmonary edema and frothing at the mouth have a poor prognosis.

Signs of PBI might only become apparent several hours after injury occurs; patients should be observed for at least 8 hours before they are discharged from the healthcare facility.

What Do I Need to Tell the Patient/Patient’s Family?

Emphasize the need to seek immediate medical attention for new or worsening signs and symptoms.

Advise patients with tympanum rupture to avoid putting any object in the auditory canal, swimming, and immersing head in water and to use ototopical antibiotics, as prescribed.

Encourage joining a support group for contact with others who face similar health challenges.
References


