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AHC Media

Civilian Blast Injury

Blast injuries are commonly thought of as incidents that occur in other countries, not here in the United States. The majority of clinicians are not prepared to deal with the devastation of a civilian blast incident and the resulting injury patterns. The author reviews expected injury patterns, triage decisions, and current therapies.

— Ann M. Dietrich, MD, Editor

Introduction

With more than 54 local wars and armed conflicts in the first decade of this century[1] and notable terrorist activity in Afghanistan, Great Britain, India, Iraq, Pakistan, and Spain, it is easy to see why many American clinicians view terrorist blast injuries as an overseas issue. However, in the two decades from 1983 to 2002, more than 36,110 criminal bombing incidents occurred in the United States. During the decade between 1992 and 2002, more individuals were injured or killed by bombs on U.S. soil than all of the U.S. citizens killed during this same period in terrorist events overseas.[2]

High-profile terrorist bombings leading to mass casualties have occurred on American soil. In the past two decades, the 1995 bombing of the Murrah Federal Building in Oklahoma resulted in 759 injuries and 168 deaths;[3] the 2001 World Trade Center bombing in New York led to nearly 4,000 casualties and 3,000 deaths;[4,5] and most recently, in 2013, three people were killed and 264 injured when two improvised explosive devices (IEDs) were detonated at the Boston Marathon.[6]

Conventional explosive devices, either traditional or improvised, remain the terrorists' weapon of primary choice,[7] and blast injury is the common result. Despite these facts, we are relatively unprepared as emergency providers and systems to treat mass casualties as a result of blast injuries.[2,3,7,8] This review provides a primer on the physics, common injury patterns, and triage for blast injury.

Physics

Terrorist explosive devices are often weapons of convenience. These devices are categorized as high-energy or low-energy.[9] Examples of high-energy explosives include trinitrotoluene (TNT), plastic explosives such as C-4, and fertilizer-based explosives. The Oklahoma City bombing was the result of a high-energy explosive: the combination of nitrate fertilizer and fuel oil configured for maximum explosive effect as fuel-air explosive.[10]

Low-energy explosives include black powder and petroleum products. The World Trade Center explosions were the result of fuel-filled commercial aircraft. The Boston Marathon bombers probably used a combination of black powder, nails, and ball bearings packed into pressure cookers detonated with standard egg timers.[11]

High-energy explosives create a blast effect as the result of transient overpressurization. A brief period of high pressure is followed by a transient low pressure of longer duration, which can suck debris into the scene of injury. The

Executive Summary

- Secondary to the multiple simultaneous mechanisms of injury, the blast patient is often more seriously injured than his multiple trauma cohort, and there is a "multidimensionality of injury" in these patients, largely because primary, secondary, tertiary, and quaternary blast effects may impact the victim simultaneously.
- Delayed injury, although uncommon, is really a delay of injury presentation. These injuries are typically primary blast injuries to the hollow organs, which do not manifest on initial roentgenogram, but should be anticipated based on clinical presentation and mitigated by careful observation and reassessment.
- The mid-facial skeleton contains large air-filled cavities and is susceptible to the spalling effects of the blast wave and implosion, resulting in "crushed egg shell" fractures of the sinus walls.
- Tympanic membrane (TM) rupture is common because of the relatively low pressure needed to perforate an eardrum.
- Research has shown that patients with skull fracture, burns greater than 10% of the body surface, and penetrating injuries to the head or torso were more likely to suffer a blast lung injury, and require early critical intervention at a level 1 trauma center.

Table 1. Classification of Blast Injuries[13,50]

Classification	Type	Mechanism	Typical Injuries
Primary	Blast wave		
	Implosion	Air-filled structures rupture from over-pressurization	Tympanic membrane rupture, blast lung, GI rupture
	Spalling	Explosive energy transfer in tissue interfaces of differing density	Lung, liver, brain contusion
	Inertia	Acceleration and deceleration forces lead to shearing injury	Mesenteric tears, axonal injury
Secondary	Blast wind	Bomb fragments, displaced foreign bodies	Penetrating or blunt multi-system injury
Tertiary	Blast wave and wind	Individual or structure thrown or crushed	Blunt or penetrating multi-system injury
Quaternary	By-products of explosion	Fireball and toxic agents	Burns and inhalation injuries

Classification of blast injury based on the mechanism of blast effect, based on the Zukerman classification developed during WWII[13] and modified from Plurad[50]

result is a shock wave that travels at supersonic speeds and a blast wind. The leading edge of this shock wave can injure tissue in its path (primary blast injury) by implosion, spalling, and inertia. The blast wind can move objects in its path, resulting in secondary blast injuries from flying debris and projectiles, or tertiary blast injuries from victims or objects that are hurled or structures that collapse. Quaternary blast injury results from the by-products of combustion such as burns and inhalation injuries.[8,9,12] (*See Table 1.*)

In the open air, blast energy rapidly dissipates with distance in inverse relation to the cube of the distance from the blast. For this reason, the distance from the blast is important in predicting injury and subsequent survival.[8,13] The Department of Homeland Security published a Bomb Stand-off Chart, which provides estimated safe distances from ground zero for a given TNT equivalent. (*See Table 2.*) The blast effect is magnified in water by an estimate of three times, and because water is less compressible than air, the wave travels for a greater distance.[8] Table 3 provides an estimate of the effect of blast over-pressurization.

Table 2. Bomb Threat Stand-off Chart

Threat Description Improvised Explosive Device (IED)	Explosives Capacity[1] (TNT Equivalent)	Building Evacuation Distance[2]	Outdoor Evacuation Distance[3]
Pipe bomb	5 lbs	70 ft	1200 ft
Suicide bomber	20 lbs	110 ft	1700 ft
Briefcase/suitcase	50 lbs	150 ft	1850 ft
Car	500 lbs	320 ft	1500 ft
SUV/van	1000 lbs	400 ft	2400 ft
Small moving van/ delivery truck	4000 lbs	640 ft	3800 ft
Moving van/water truck	10,000 lbs	860 ft	5100 ft
Semi-trailer	60,000 lbs	1570 ft	9300 ft

1. These capacities are based on the maximum weight of explosive material that could reasonably fit in a container of similar size.
2. Personnel in buildings are provided a high degree of protection from death or serious injury; however, glass breakage and building debris cause some injuries. Unstrengthened buildings can be expected to sustain damage that approximates five percent of their replacement cost.
3. If personnel cannot enter a building to seek shelter, they must evacuate to the minimum distance recommended by Outdoor Evacuation Distance. This distance is governed by the greater hazard of fragmentation distance, glass breakage, or threshold for ear drum rupture.

Source: Department of Homeland Security

Department of Homeland Security Bomb Threat Stand-off Chart. This chart provides an estimate of safe distance from the blast epicenter for a given charge of TNT. Note that 5 pounds of TNT is dangerous at up to a quarter mile. Further detail is available from dhs.gov.

Closed spaces significantly modify and amplify the blast effect. Walls and other hard surfaces reflect the wave and extend its duration, leading to a greater transfer of energy to susceptible organ systems.[13,14] Low-energy explosives can also have a primary blast effect, which is quickly mitigated by distance, and injuries are usually due to secondary and tertiary blast effects. In the Centennial Olympic Park bombing in 1996, advance warning and a low-energy explosive allowed for an orderly evacuation, which minimized casualties.[15]

Initial Assessment

The initial assessment and management of patients with blast injuries does not differ from the management of any multiple-injury trauma victim, and should follow standard Advanced Trauma Life Support (ATLS) principles.[16] There are, however, some differences in injury patterns and potential pitfalls specific to the organ systems involved, which will be discussed below. (*See Table 4.*) An understanding of the mechanism of injury is especially critical to understanding and managing the patient who has sustained a blast injury. The explosive agent used, the medium of wave propagation (air vs. water), the presence of flying debris and shrapnel, distance from the blast, open vs. closed environment, building collapse, and fire all provide different wounding mechanisms and morbidity and mortality rates.[8,12-14]

Additionally, because of the multiple simultaneous mechanisms of injury, the blast patient is often more seriously injured than his or her multiple trauma cohort, and there is a "multidimensionality of injury" in these patients, largely because primary, secondary, tertiary, and quaternary blast effects may impact the victim simultaneously.[8] This means time is of the essence and the opportunity for missed injury is magnified. Delayed injury, although uncommon, is really a delay of injury presentation. These injuries are typically primary blast injuries to the hollow organs, which do not manifest on initial roentgenogram, but should be anticipated based on clinical presentation and mitigated by careful observation and reassessment.[12] (*See Tables 4 and 5.*)

Maxillofacial Skeleton

The most common injuries are blunt and penetrating trauma as a result of secondary and tertiary blast effects. However, the blast wave can cause differential acceleration/

Table 3. Blast Pressure Effects

Pressure (kPa)	Effect
30	Shatters glass
100	50% chance of tympanic membrane rupture
200	100% tympanic membrane rupture, minimum pressure for lung injury
500	50% chance of lung injury
900	50% chance of death
2000	Lethal

Adapted from Boffard and MacFarlane.[31] The blast effects are governed by the size and type of charge, distance from the blast, and the medium of propagation. For example, 25 kg of TNT produces 1500 kPa (150 psi) of over pressure for 2 milliseconds at the epicenter and travels at up to 8,000 meters/second.[51] The resultant blast wind can be of hurricane proportions.[31]

Figure 1. Subdural Hematoma

Reprinted with permission from: Werman H, Kube E. Evaluation and management of blunt trauma patients in the emergency department. *Emerg Med Rep* 2008;29:305.

deceleration forces (inertia), which can lead to transverse shearing fractures of the mandible.[1] The mid-facial skeleton contains large air-filled cavities and is susceptible to the spalling effects of the blast wave and implosion. This may result in "crushed egg shell" fractures of the sinus walls.[1] Isolated maxillofacial injury rarely leads to death, and should be managed as appropriate within the context of the victim's other injuries.

Ear

Injury to the external ear is usually the result of secondary, tertiary, or quaternary blast injury.[17] The blunt and penetrating injuries require appropriate wound care, debridement, and repair. Injuries to the middle and inner ear are often the result of primary blast injury. Hearing loss, tinnitus, and ear pain are common and often temporary. Vertigo is unusual and should suggest the possibility of concomitant head injury.[17,18] Tympanic membrane (TM) rupture is common because of the relatively low pressure needed to perforate an eardrum. (*See Table 3.*) Ossicular injury is uncommon and suggests significant trauma.[17] The physical examination should include a hearing evaluation.[17] Most TM ruptures will heal spontaneously; however, referral to an otolaryngologist is appropriate.[17,18]

The common wisdom has been that a TM injury is a harbinger of potential occult primary blast injury. Recent evidence, however, suggests that while TM injury is common, its presence or absence does not include or exclude other injuries.[9,17,19,20] In the survivors of the 2005 London bombings, TM rupture as a biomarker of concealed primary blast injuries had a sensitivity and specificity of 50%, and a low positive predictive value. External evidence of injury may be a more appropriate triage tool.[21]

Eye

Primary blast injury to the eye can lead to globe disruption, retinal injury, and hyphema.[14] However, penetrating injury from flying debris and shrapnel as the result of secondary blast injury is the more common cause of eye injury.[22,23] One major receiving center from the 2004 Madrid bombing reported an incidence of ocular injury in 16% of their patients with minor injuries and 15% of their patients with critical injuries.[24] Ocular injury was the second most common injury (26%) in the injured survivors of the 2001 World Trade Center bombing.[4] Symptoms include loss of visual acuity, eye pain, and foreign body sensation. Appropriate wound care should be provided for external injuries. Emergency management for injury to the globe (evaluation, irrigation, topical antibiotics, and patching) should be followed with specialty evaluation and management for complex injuries.

Brain

Brain injury is a common cause of death in blast injury. One hundred sixty-seven people died as a result of the Oklahoma City bombing in 1995. Head injury was the second most common cause of death (14%), with multiple trauma the leading cause (73%). Fifty-two percent of critically injured patients treated at the closest hospital during the 2004 Madrid bombings sustained head injuries.[24] Blunt and penetrating injury can result from primary, secondary, and tertiary blast effects.[23] Blunt injury can range from concussion to diffuse axonal injury;

Table 4. Overview of Explosion-related Injuries

System	Injury or Condition
Auditory system	Tympanic membrane rupture, ossicular disruption, cochlear damage, foreign body
Cardiovascular	Cardiac contusion, myocardial infarction from air embolism, shock, vasovagal hypotension, peripheral vascular injury, air embolism-induced injury
Extremity injuries	Traumatic amputation, fractures, crush injuries, compartment syndrome, burns, cuts, lacerations, acute arterial occlusion, air embolism-induced injury
Gastrointestinal	Bowel perforation, hemorrhage, ruptured liver or spleen, sepsis, mesenteric ischemia from air embolism
Neurologic system	Concussion, closed and open brain injury, stroke, spinal cord injury, air embolism-induced injury
Ocular injury	Perforated globe, foreign body, air embolism, fracture
Renal injury	Renal contusion, laceration, acute renal failure due to rhabdomyolysis, hypotension, and hypovolemia
Respiratory system	Blast lung, hemothorax, pneumothorax, pulmonary contusion and hemorrhage, A-V fistulas (source of air embolism), airway epithelial damage, aspiration pneumonitis, sepsis

Adapted from Centers for Disease Control and Prevention. Explosions and blast injuries: A primer for clinicians. Available at http://www.bt.cdc.gov/masscasualties/explosions.asp.

however, subarachnoid hemorrhage and subdural hemorrhages occur most frequently in fatalities.[23] (*See Figure 1.*)

Recent studies using diffusion tensor imaging suggest there is a component of axonal injury in military personnel with blast-related mild traumatic brain injury.[25] However, it is not clear if isolated primary blast injury at a distance leads to mild traumatic brain injury in the absence of a direct blow.[25-27]

Evaluation and management of head injury should follow the basics of emergency management as outlined in ATLS.[16] Because patients sustaining injury as a result of a blast are more critically injured than their multisystem trauma cohort,[8] avoidance of hypoxia and hypotension are essential, and the early involvement of neurosurgical specialists in the initial management is appropriate.

Chest

Blast lung injury (BLI) implies proximity to the blast and is a common cause of mortality at the scene of bomb blasts.[9] (*See Figure 2.*) It is also a frequent cause of morbidity for survivors.[28,29] Avidan et al analyzed a two-decade experience with BLI and found a 71% incidence of BLI in blast victims admitted to the intensive care unit (ICU) of their Israeli trauma center.[28]

The blast wave causes a combination of implosion, inertia, and spalling, which can lead to bronchoalveolar disruption, pulmonary contusion, and arterial air emboli.[9,21,28,29] Survivors generally present with hypoxemia and respiratory distress.[29] Bloody sputum and evidence of barotrauma (pneumothorax) are not uncommon, even though radiologic evidence may lag by 12 to 24 hours.[12] Secondary injury may also lag presentation by several hours. Eckert et al advocate observation for at least 18 hours and selected bronchoscopy to evaluate quaternary airway injury based on their experience at a combat support hospital in Iraq.[30]

Penetrating injuries as a result of flying debris and projectiles, blunt injuries as a result of falls and crush injuries, and inhalation injury and burns should be managed emergently with ATLS principles.[16] Definitive management should be provided with advanced pulmonary and surgical critical care.

Abdomen

Abdominal blast injury can be both blunt and penetrating. In the 2004 Madrid bombings, 12 of the 243 patients (5%) and 10 of 27 (37%) critically injured patients treated at the nearest hospital sustained abdominal injuries.[24] The

Table 5. Clinical Signs and Symptoms of Explosion-related Injuries

System	Injury or Condition
Auditory system	• Blood oozing from the mouth, nose, or ears* • Eardrum hyperemia, hemorrhage, or rupture* • Deafness* • Tinnitus* • Earache*
Cardiovascular	• Tachycardia • Fall of mean arterial blood pressure
Gastrointestinal	• Nausea* • Abdominal tenderness* • Abdominal rigidity*
Neurologic system	• Vertigo • Retrograde amnesia
Ocular injury	• Eye irritation** • Hyphema** • Distorted pupil** • Decreased vision** • Blindness** • Funduscopic findings of retinal artery air embolism**
Respiratory system	• Cyanosis* • Ecchymosis or petechiae in hypopharynx* • Cough (often dry)* • Tachypnea (often preceded by a short period of apnea)* • Dyspnea* • Hemoptysis* • Rales or moist crepitation in lung fields* • Chest pain*

* Most common findings

** Common findings

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experience in the Oklahoma City bombing in 1995 was quite different. Four of a total of 759 patients sustained life-threatening abdominal injuries: one bowel transection, two splenic lacerations, one kidney laceration, and one liver laceration.[10] (*See Figures 3 and 4.*) Both of these bombings involved high-energy explosives, but the mechanisms were quite different. In Madrid, suicide bombers used military explosives and shrapnel to detonate in a closed space at close proximity.[24] As expected, the injuries included a combination of blunt and penetrating trauma, and were relatively common in seriously injured survivors. In Oklahoma City, the explosive was an improvised fuel-oil bomb,[10] and the abdominal injuries were blunt and uncommon.

Primary blast injury is relatively uncommon in survivors. Implosion can rupture air-filled bowel wall, spalling forces can disrupt viscera at tissue interfaces (i.e., lung/liver, or spleen), and shearing forces associated with inertia typically affect mesentery.[8,12,31] These effects are significantly increased under water.[32] The emergency management of these patients does not change from the management of the multiple-injury patient, except as mentioned above.

Extremities

Soft-tissue injury accounts for the majority of trauma in civilian blast events.[33] In the Oklahoma City bombing, soft-tissue trauma was the most common injury, followed by fractures and dislocations.[3] Primary blast injury has been shown to cause fractures and amputations;[34] however, the most common cause of extremity injury is related to secondary and tertiary blast effects. Injuries can range from simple soft-tissue trauma to amputations. In the military experience in Afghanistan and Iraq, extremity fractures accounted for 82% of combat injuries, and the majority of the fractures were open.[35] In the civilian bombings, the incidence of extremity injury is much lower. In the Madrid bombings of 2004, only 17% of survivors sustained extremity fractures, and only one patient sustained a traumatic lower extremity amputation.[24] Civilian traumatic amputations as a result of blast injury, however, are often lethal because the blast energy required to amputate a limb is usually lethal to other organ systems.[12,36,37] This was illustrated in the 2005 London bombing in which six of seven patients with traumatic amputations of the upper extremity died at the scene.[36] Almogy et al reported a three-year experience with 15 suicide bombings in Israel.[21] In their series, 63 of 74 (85%) patients with traumatic amputations died at the scene. The Boston bombings of 2013 resulted in several amputations, but few fatalities. These blasts were low-energy and in the open air.

Evaluation should proceed by standard ATLS protocols.[16] Special consideration should be given to

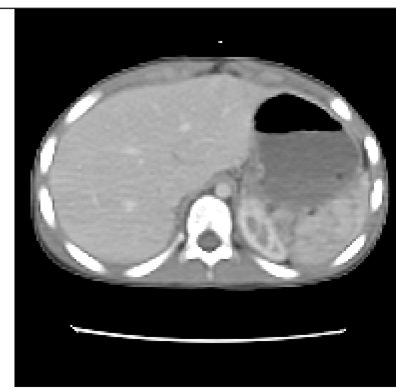
Figure 2. Blast Lung

Reprinted with permission from: Wolf YG. Vascular trauma in high-velocity gunshot wounds and shrapnel-blast injuries in Israel. *Surg Clin North Am* 2002;82:237-244.

Figure 3. Liver Laceration

Reprinted with permission from: Wang NE, Blankenburg RL. Pediatric abdominal trauma. *Trauma Rep* 2007;8:7.

Figure 4. Spleen Fracture



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the surrounding environment and the potential for contamination and secondary infection.[23] One unique aspect of terrorist bombing is the potential for biologic foreign bodies and the risk of blood-borne disease these biologic fragments may carry.[38] Tourniquets are often discouraged in civilian practice, but can be life-saving in traumatic amputations. Surgical completion of the amputation is often a difficult decision, but should be made based on the potential viability and projected functionality of the injured extremity.[35,36]

Pregnancy

Blast injury in pregnancy is uncommon. Mallonee et al reported three of the 167 deaths (1.8%) in the Oklahoma City bombing were pregnant women.[10] Marti et al reported one maternal fetal death from massive hemoperitoneum in 36 patients (3%) treated at their institution following the 2004 Madrid bombings.[39] The fetus may be cushioned by amniotic fluid; however, the placenta would be subject to implosion and shearing forces,[14,40] and the mother would be subject to all of the other mechanisms and injuries described above. Initial assessment and management should follow standard ATLS protocols.[16] Postmortem cesarean section for blast injury is rare, but should be considered for the viable fetus in the case of sudden maternal death.[41]

Burns

The primary blast is associated with a brief fireball at detonation.[23] These burns are often lethal[14] because they herald a close proximity to the blast[12] and are associated with the other primary blast injuries discussed above. Burns and inhalation injuries make up the majority of quaternary blast injuries.[14] Among the 790 injured survivors in the World Trade Center attack in 2001, 386 (49%) were treated for smoke inhalation.[4] The combination of burns and inhalation injuries with the constellation of other injuries sustained by these patients can make them difficult to manage.[12]

Triage

Mass casualty events as the result of a blast are dramatic events and muster an immediate and often less than coordinated response. Despite this, the vast majority of survivors are walking wounded (*see Table 6*), and the over-triage rate is typically 50-90%.[43] Additionally, the receiving

Table 6. Civilian Blast Event Severity of Injury

Event and Year (Reference)	Casualties	Dead	Treated		Explosive
			Hospitalized	Released	
Oklahoma City 1995[10]	759	168 (22%)	83 (14%)	508 (86%)	Fertilizer and fuel oil
Atlanta Olympics 1996[15]	111	1 (<1%)	24 (22%)	87 (78%)	Pipe bomb and shrapnel
World Trade Center 2001[4,5]	3922	2819 (72%)	181 (17%)	810 (73%)	Jet fuel
Madrid 2004[24]	2000	191 (10%)	91 (29%)	221 (71%)	Military explosives and shrapnel
London 2005[42]	775	56 (7%)	27 (14%)	167 (86%)	Military explosives and shrapnel
Boston Marathon 2013[6]	267	3 (1%)	20 (8%)	244 (92%)	Black powder and shrapnel

Casualties for the World Trade Center attack and the Madrid bombings are estimates based on the available literature. Disposition of casualties at the hospital for Madrid and London are based on single institutional experience. The differences in mortality are related to the explosive agent used (high-energy vs. low-energy), open vs. closed space, and high-rise vs. ground level.

facility for the largest influx of patients is often the nearest facility and not necessarily the facility most capable of handling the injuries.[42] Triage at the scene should be performed by experienced personnel, and patient distribution allocated based on available resources and patient need.[42] Triage at the receiving facility should also be done by experienced clinicians and with the understanding that most of the patients seen will not be critically injured.[42,43]

Although injury to the tympanic membrane is the most common blast injury and has been heralded as a harbinger of more serious blast injury, the correlation doesn't hold. It is a poor diagnostic tool for triage. Serious injury is usually obvious. The mechanism is a more important predictor for occult injury, and history becomes an important indicator of blast exposure. The combination of mechanism and evidence of external injury can often help to identify those patients in need of critical resources. (*See Table 7.*) Almogy et al described a retrospective analysis of 15 suicide bomb attacks treated over a three-year period (1994-1997) in Israeli hospitals.[21] These authors found that patients with skull fracture, burns greater than 10% of the body surface, and penetrating injuries to the head or torso were more likely to suffer a blast lung injury, and would require early critical intervention at a level 1 trauma center.

The initial management of these patients should follow damage-control principles to allow for the greatest good to the largest number of victims.[13,42,43] Resource allocation for definitive management will typically mirror those resources used in trauma; however, the seriously injured are a magnitude of several times more severely injured than their typical multi-system counterparts. Experience from military conflicts can help to guide their management.[44] In the Oklahoma City bombing, general surgery, ophthalmology, orthopedics, neurosurgery, and vascular surgery were utilized (in decreasing order) for patients needing operative intervention.[3]

Although it is counter-intuitive, blood usage is not out of proportion to the injury and does not exceed local resources.[42,44] Predictive models from military[44] and civilian experience[13,39,42,43,45-49] may help with disaster planning and allocation of resources.

There are a number of excellent courses to help emergency providers better understand the basics of mass casualty and its management. These include: The National Disaster Life Support™ (NDLS™) course from the National Disaster Life Support Foundation (formerly a collaboration with the AMA); Collaborative Disaster Planning Processes from the American College of Emergency Physicians (ACEP) and the Federal Emergency Management Agency (FEMA); and Disaster Management and Emergency Preparedness (DMEP) from the American College of Surgeons Committee on Trauma Disaster and Mass Casualty Management Committee.

Table 7. Considerations for Injury Severity

Blast Force	
• Explosive energy (high-energy vs. low-energy)	
• Distance from ground zero	
• Energy dissipates by the cube of the distance from the blast	
Environment	
• Building collapse (high-rise vs. low-rise)	
• Confined space vs. open air explosions	
• Urban vs. rural (less population dense) settings	
Projectiles	
• Environmental debris vs. intentional shrapnel	
By-products of explosion	
• Fire	
• Smoke	
• Toxins	
Anatomic Markers of Severe Injury	
• Traumatic amputation	
• Blast lung injury	
• Severe head injury	
• Torso trauma	
• Multidimensional injury	

Adapted from Ciraulo DL, Frykberg ER. The surgeon and acts of civilian terrorism: Blast injuries. *J Am Coll Surg* 2006;203:942-950.

Conclusion

Blast injury provides a unique challenge in management. There are often multiple survivors, and many of them have minor injuries. This can lead to a dramatic surge in patient inflow to the facility closest to the event. The seriously injured patient can be subjected to a multitude of mechanisms, including primary, secondary, tertiary, and quaternary blast. They are often more severely injured and more complex in their presentation than their multiple trauma counterparts. The emergency provider should understand and anticipate the basics of blast injury to provide optimum care. Continuing education in mass casualty and disaster management is strongly encouraged.

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CNE/CME Objectives

Upon completing this program, the participants will be able to:

- discuss conditions that should increase suspicion for traumatic injuries;
- describe the various modalities used to identify different traumatic conditions;
- cite methods of quickly stabilizing and managing patients; and
- identify possible complications that may occur with traumatic injuries.

CNE/CME Instructions

HERE ARE THE STEPS YOU NEED TO TAKE TO EARN CREDIT FOR THIS ACTIVITY:

1. Read and study the activity, using the provided references for further research.
2. Log on to **www.cmecity.com** to take a post-test; tests can be taken after each issue or collectively at the end of the semester. *First-time users will have to register on the site using the 8-digit subscriber number printed on their mailing label, invoice, or renewal notice.*
3. Pass the online tests with a score of 100%; you will be allowed to answer the questions as many times as needed to achieve a score of 100%.
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5. **Once the completed evaluation is received, a credit letter will be e-mailed to you instantly.** You will no longer have to wait to receive your credit letter.

CME/CNE Questions

1. Blast-injured patients are more seriously injured than their multiple-trauma counterparts because of:

   A. primary blast injury
   B. secondary blast injury
   C. tertiary blast injury
   D. quaternary blast injury
   E. all of the above

2. Tympanic membrane rupture is an accurate predictor of occult primary blast injury.

   A. true
   B. false

3. Which of the following is (are) the best predictor(s) of occult primary blast injury?

   A. tympanic membrane rupture
   B. external injury
   C. mechanism of injury
   D. B and C
   E. none of the above

4. The most common cause of blast injury is:

   A. primary blast injury
   B. secondary blast injury
   C. tertiary blast injury
   D. quaternary blast injury
   E. quintenary blast injury

5. Explosions are dramatic events, but over-triage is uncommon.
   A. true
   B. false

6. Blast-injured patients at the scene of a mass casualty event should be routinely transferred to a trauma center.
   A. true
   B. false

7. In a blast injury mass casualty situation, management should include:
   A. scene transfer to a trauma center
   B. damage-control principles
   C. hospitalization and observation of all victims evaluated in the ED to exclude occult blast injury
   D. all of the above
   E. none of the above

8. Traumatic amputation is often:
   A. a lethal injury in civilian experience
   B. survivable in the recent military experience
   C. associated with other severe blast injuries
   D. best managed with damage-control principles
   E. all of the above

9. Which of the following is true?
   A. Quaternary blast injury is uncommon in survivors.
   B. Infectious risk does not differ from other multiple-injury patients.
   C. Burn patients are managed identically to non-blast counterparts.
   D. All of the above are true.
   E. None of the above are true.

10. Which of the following is true of primary blast lung injury?
   A. It is usually evidenced on admission with clinical findings.
   B. It uniformly occurs with blast over pressures of 300 psi.
   C. It may be associated with quaternary blast effect on the airways.
   D. A and C are true.
   E. None of the above are true.

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