

IEDs and the Management of Civilian Casualties; Belfast to Boston

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Objectives

- Understand impact of IEDs on civilian populations
- Learn history and impact of recent IED Civilian events
- Review the patterns of injury
- Learn effective first responder to EMS interventions
- Define role in Organizational Response

Outline

- IEDs definitions and types
- IED events of past 50 years
- IED construction types encountered
- Patterns of blast wounding
- Special categories
 - “dirty” bombs
- IED response planning in personnel and equipment
- Interorganizational Response
 - Fire/Police/EMS/Federal/Military

Improvised Explosive Devices

- An explosive device constructed and deployed in ways other than in conventional military action
- May be based on production or home made explosives
- Employed increasingly by sub national terrorist groups or individuals without access to conventional weapons
- Recent military casualties 2/3rds from improvised, non conventional weapons
- Developed to delay, distract, or destroy an opposing force
- Recently as means of Terrorism

IEDs in Terrorism

- Magnifies death and injury for each event

IEDs in Terrorism

- Focus on Private Citizens

IED Types and Civilian Incidents

- Improvised explosive devices (IEDs)
 - Car and truck bombs (Oklahoma City, World Trade Center I)
 - Letter and parcel bombs (Idaho “Unabomber”)
 - Pipe bombs (Atlanta Olympics)
 - Backpack and satchel bombs (Israel, London)
 - Pressure Cooker bombs (Boston)
 - Airplane bombs (World Trade Center II, Pentagon)

Background: Blast Agents

High-order explosive: HE (Blast Wave)

- Nitroglycerin (NTG)
- Dynamite
- Plastic
- Ammonium nitrate/ fuel oil (ANFO)
- Trinitrotoluene (TNT)
- Triacetone triperoxide(TAPT)

Background: Blast Agents

Low-order explosive: LE (No Blast Wave)

- Petroleum products
(“Molotov cocktail”)
- Gunpowder
(“black” powder)
- Easy to make
- Schrapnel and incendiaries add to effect
- Can become HE, if contained (e.g., pipe bomb)

United Kingdom/Republic of Ireland

- The Troubles
- Provisional IRA made extensive use of IEDs in their 1969–97 campaign.
 - developed and counter-developed devices and tactics
 - became highly sophisticated, featuring anti-handling devices (mercury tilt switch), and anti-jamming devices
 - electronic delays could be set to accurately detonate a bomb weeks after it was hidden (Brighton hotel bomb attack of 1984)
- Roadside bombs were extensively used by the IRA forcing Britain to switch from ground surveillance to helicopter
- used secondary devices to catch British reinforcements sent in after an initial blast (Warrenpoint Ambush).
- Between 1970 and 2005, the IRA detonated 19,000 IEDs in the Northern Ireland and Britain,
 - avg one every 17 hours for three and a half decades
 - "the biggest terrorist bombing campaign in history"

Historically in US...

- Few US bombings have caused mass casualties
 - First World Trade Center Attack, February 1993
 - Oklahoma City Bombing – April 19, 1995
 - Fuel and fertilizer used to create a bomb
 - 518 injuries and 168 deaths
 - Atlanta Olympic Park Bombing, July 27, 1996
 - Army of God Bombings 1997
 - Targets abortion Clinics and Gay Bars
 - Dual bombs with delay, second set to kill first responders
 - World Trade Center and Pentagon
 - September 11th, 2001
 - Explosive Device Attacks at Abortion Clinics
 - Boston Marathon Bombing, April 15, 2013
 - Mimicked battlefield casualties

United States

- Oklahoma City 1995
- IED with ammonium nitrate fertilizer, nitromethane, and stolen commercial explosives in a rental truck, with sandbags used to concentrate the explosive force in the desired direction detonated next to the Alfred P. Murrah Federal Building, 518 injuries, killing 168 people, 19 of whom were children.

United States

Boston 2013

- Double bombing 12 seconds apart
- 3 dead
- 264 injured
- 152 patients who presented to the ED within 24

Device Types

- Explosive
- Incendiary
- Chemical
- Biological
- Radiological
 - Dirty Bomb
 - americium-241, californium-252, caesium-137, cobalt-60, iridium-192, plutonium-238, polonium-210, radium-226 and strontium-90
 - Chechnya
 - May not produce immediate casualties
 - Contamination may persists after decon

Types of Blast Injuries

- Primary
 - Due to direct effect of pressure
- Secondary
 - Due to effect of projectiles from explosion
- Tertiary
 - Due to structural collapse and from persons being thrown from the blast wind
- Quaternary
 - Burns, inhalation injury, exacerbations of chronic disease

Primary Blast Injury

Unique to high explosives

- Due to impact of over-pressurization wave with body surfaces
- Atomizes tissue
- Most commonly involve air-filled organs and air-fluid interfaces
 - Middle ear
 - TM rupture/hemorrhage
 - Lungs (most common fatal cause in primary blast survivors)
 - PTX, Pulm Contusion, Air Embolism (avoid high pressure vent)
 - Gastrointestinal tract
 - Worse in underwater explosions
 - Infarct/perforation
 - Eye
 - ¼ victims have injury
 - Globe rupture
 - Brain
 - Traumatic brain injury (TBI) without physical signs of head injury
 - Air embolism

Secondary Blast Injury

- Due to flying debris and bomb fragments
- Penetrating ballistic or blunt injuries
 - Leading cause of death in civilian terrorist attacks except in cases of major building collapse
 - Wounds can be grossly contaminated
 - Consider delayed primary closure and tetanus vaccinations

Tertiary Blast Injuries

- Due to persons being thrown into fixed objects by wind of explosions
- Also due to structural collapse and fragmentation of building and vehicles
- Structural collapse may cause extensive blunt trauma
 - Crush syndrome
 - Damage to muscles and subsequent release of myoglobin, urates, potassium, and phosphates
 - Oliguric renal failure
 - Compartment syndrome
 - Edematous muscle in an inelastic sheath promotes local ischemia, further swelling, increased compartment pressures, decreased tissue perfusion, and further ischemia

Quaternary Blast Injuries

- Explosion related injuries or illnesses not due to primary, secondary, or tertiary injuries
 - Exacerbations of preexisting conditions, such as asthma, COPD, CAD, HTN, DM, etc.
 - Burns (chemical and thermal)
 - White Phosphorous (WP) from munitions causes extensive burns, hypocalcemia and hyperphosphatemia (1% Cu solution lavage)
 - Toxic inhalation
 - Radiation exposure
 - Asphyxiation (carbon monoxide and cyanide)

Blast Injuries: Unique Aspects

- Inflict multi-system injuries on large groups of people
- Cause many simultaneous life-threatening injuries
- Hidden pattern of injury

Blast Physics

Importance of Injury Types vs. Distance

Blast Injury: Severity

- Nature of device – agent, amount
- Method of delivery – incendiary, explosive
- Nature of environment – open, closed
- Distance from device
- Intervening protective barrier
- Other environmental hazards

Blast Injuries: Pathophysiology

Proposed mechanisms*

- Spalling
 - Caused by shock wave moving through tissues of different densities → molecular disruption
- Implosion
 - Caused by entrapped gases in hollow organs compressing then expanding → visceral disruption

Blast Injuries: Combined Injuries

- Avoid tunnel vision during initial assessment
- Treatment protocols are often contradictory
 - Blast lung vs. burn injury, blast lung vs. crush injury
- Judicious fluid administration for adequate tissue perfusion without volume overload may be required in the multiple injured patient with blast lung
 - Presence of additional injuries complicates administration, rate, selection of fluids

Blast Injury: Combined Injuries

Typical confined space (e.g., a bus) injuries

- Primary—blast lung, intestinal rupture, TM rupture
- Secondary—penetrating injury to head, eye, chest, abdomen
- Tertiary—traumatic amputation, fractures to the face, pelvis, ribs, spine
- Quaternary— crush injuries, superficial and partial to full thickness burns

Crush

- 5-15% of all mass casualty injuries
- Predominantly extremities and abdomen
- Initial
 - High degree of pressure on a body system resulting in ischemia
- Delayed
 - Consequence of reperfusion of initial injury
 - Crush Syndrome release of toxic byproducts of ischemia
 - Potassium, Purines, Lactic Acid, Phosphate, Myoglobin, Thromboplastin, Creatine
 - Compartment Syndrome swelling of tissue in an enclosed space
 - P⁵, Local tissue death initially then Crush syndrome secondarily

Special Considerations

- Pregnancy
 - Placental abruption from primary blast
- Children
 - Smaller mass and tissue density
 - High incidence of pulmonary contusion
 - Equipment and hospital resources
- Elderly
 - Co-morbidity, medications, body mass and density
 - Increased orthopedic injuries
 - Decontamination of medical equipment
- Disabled
 - Pre-existing mobility problems, cognition
- Language barriers
 - Multinational society
- Psychological
 - Little or no warning
 - Unknown duration of the event
 - Potential threat to personal safety
 - Unknown health risks
- Sequelae from an explosive event
 - Anger
 - Frustration
 - Helplessness
 - Desire to seek revenge

Psychological Issues for Responders

- Promotion of safety
- Promote calm
- Promote connectedness
- Promote self-efficacy
- Promote hope

Explosive Events: Criminal Investigation

- Principles of criminal investigation and evidence preservation
 - Indicators for crime scene
 - Evidence and chain of custody
 - Avoid disturbing or compromising evidence
 - Detection of possible suspects/perpetrators
 - Quick identification and note taking
 - Documentation of statements by victims and witnesses

Detection and disarmament

- Because the components of these devices are being used in a manner not intended by their manufacturer, and because the method of producing the explosion is limited only by the science and imagination of the perpetrator, it is not possible to follow a step-by-step guide to detect and disarm a device that an individual has only recently developed.

Scene Safety: Common Hazards

- Secondary devices
- Shrapnel
- Building collapse
- Air-borne contaminants
- Contaminated patients
- Contaminated scene/environment
- Perpetrators
- Terrorist patients

Scene Safety: Common Hazards

- Victims with no soft tissue injuries
- Vehicles coming or leaving scene (out of place)
- People acting oddly
- Packages or containers at scene (out of place)
- Vehicles not damaged or out of place
- Structural damage
- Weather
- Possible places for secondary devices

Scene Safety:

Appropriate PPE for blasts

- Coveralls
- Heavy coat
- Heavy gloves
- Steel-toed boots
- Hard hat
- Eye protection
- Dust particle mask
- Breathing apparatus for toxic fumes

Scene Safety: Common Principles

- Contain the incident
 - Deny entry to all but responders
 - Set up zones
 - Hot
 - Warm
 - Cold
- Contain the people
 - Do not let anyone leave scene until checked
 - Decontaminate if necessary

Scene Safety: Common Principles

- Cause no further injury or destruction
- Protect yourself
- Activate command and hazard response (ICS)
- Limit access
- Contain the incident

Communications

- Information about distance from and type of explosion predict injury severity and type
 - Confined space vs. open space
 - Increased number of penetrating and primary blast injuries if closed space
 - Intensity of explosion pressure wave declines with cubed root of distance away from explosive
 - Standing at 3m has 9x greater pressure than if at 6m
 - Blast wave reflected by solid surfaces
 - Person next to a wall may sustain a greater primary blast injury

Hospital Considerations

- Half of all initial casualties seek medical care over first hour
- Large numbers of victims hinder triage and delay transport
- Expect upside down triage
 - Most severely injured arrive after less injured who bypass EMS and self-transport to closest hospitals
- Secondary devices
 - Initial explosion attracts law enforcement and rescue personnel who will be injured by second explosion

Military Experience

Medical Advances from the Global War on Terrorism

Expanded use of Damage Control Surgery

- Whole blood
- Tourniquets
- Hemostatic agents
- Hemostatic dressings

Boston Marathon Bombing

- 66 of those patients had an extremity injury.
- 29 patients had life-threatening exsanguination
 - 27 tourniquets applied (all improvised)
- 17 patients had traumatic amputations

Summary

- Increasing incidents and device types
- Unique patterns of Injury
- Multi disciplinary response Crime
- Delayed presentations
- Overwhelming of Resources
- Hemostatic control
- Psychologic impact