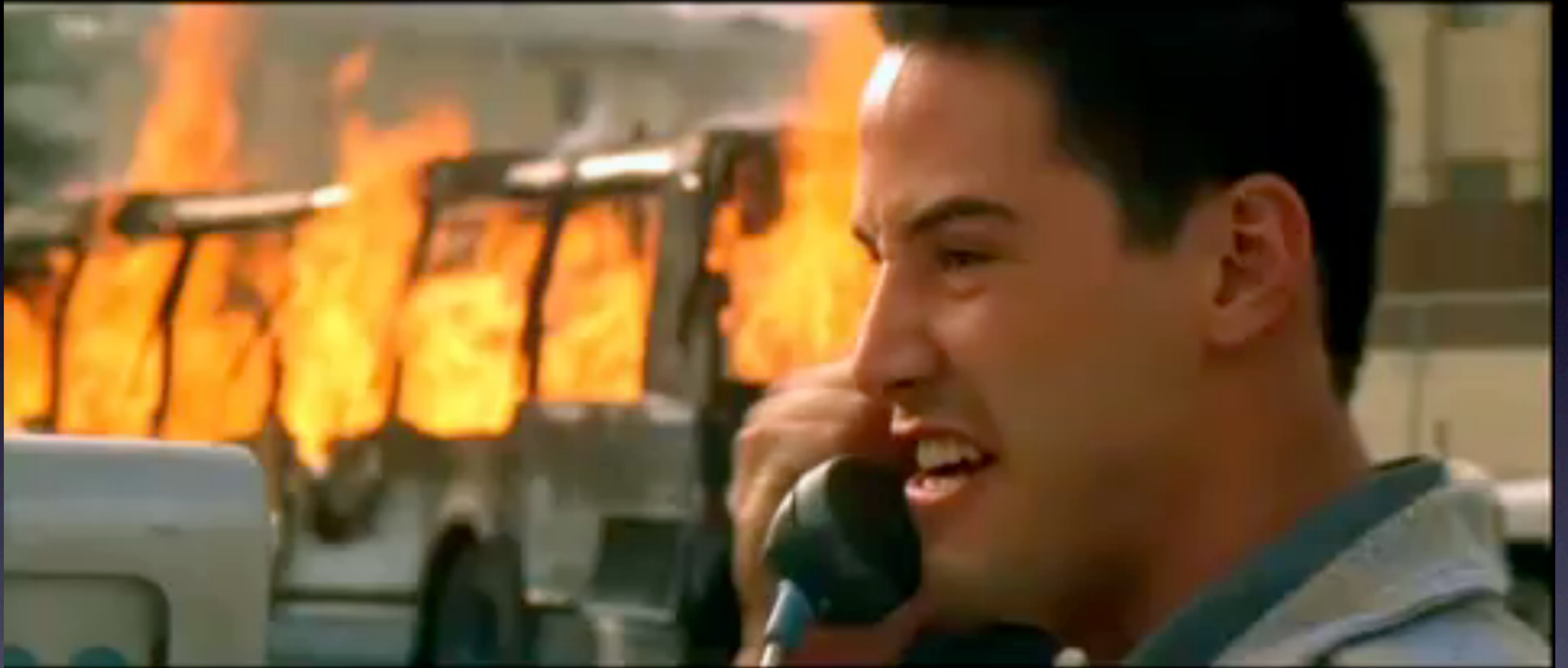


Explosive Injuries

Jeff Rabrich, DO, EMT-P
EMS Medical Director
St. Luke's - Roosevelt Hospital
New York, NY

Objectives

- Review recent bombing events in US
- Discuss Triage strategies and scene management
- Discuss the mechanism and types of injuries
- Review prehospital care of victims
- Discuss preparedness efforts



Types of Events

- Terrorism
- Criminal, non-terrorist
- Accidental
 - Industrial
 - non-industrial

Terrorism

- Defined as containing 4 key elements
 - Premeditation
 - Political
 - Aimed at civilians
 - carried out by sub-national groups

Background

- Explosives are by far the most common type of terroristic attack.
- Use of explosives increasing
- Relatively little knowledge needed to create crude device
- Small, well placed device can create maximal damage.

Historical Perspective

- 1968-1999
 - 7000 international terrorist bombings
- 1969-1980
 - 187 Bombings in Northern Ireland
- 1980-2001
 - 324 criminal bombings in US
- 2001-2003
 - 500 international terrorist bombings

2005 alone

- 399 international terrorist bombings

Recent Events

- Mumbai (2006)
- Tel Aviv (2006)
- London Subway (2005)
- Madrid Subway (2004)
- Tel Aviv (2001)

MUMBAI 2006

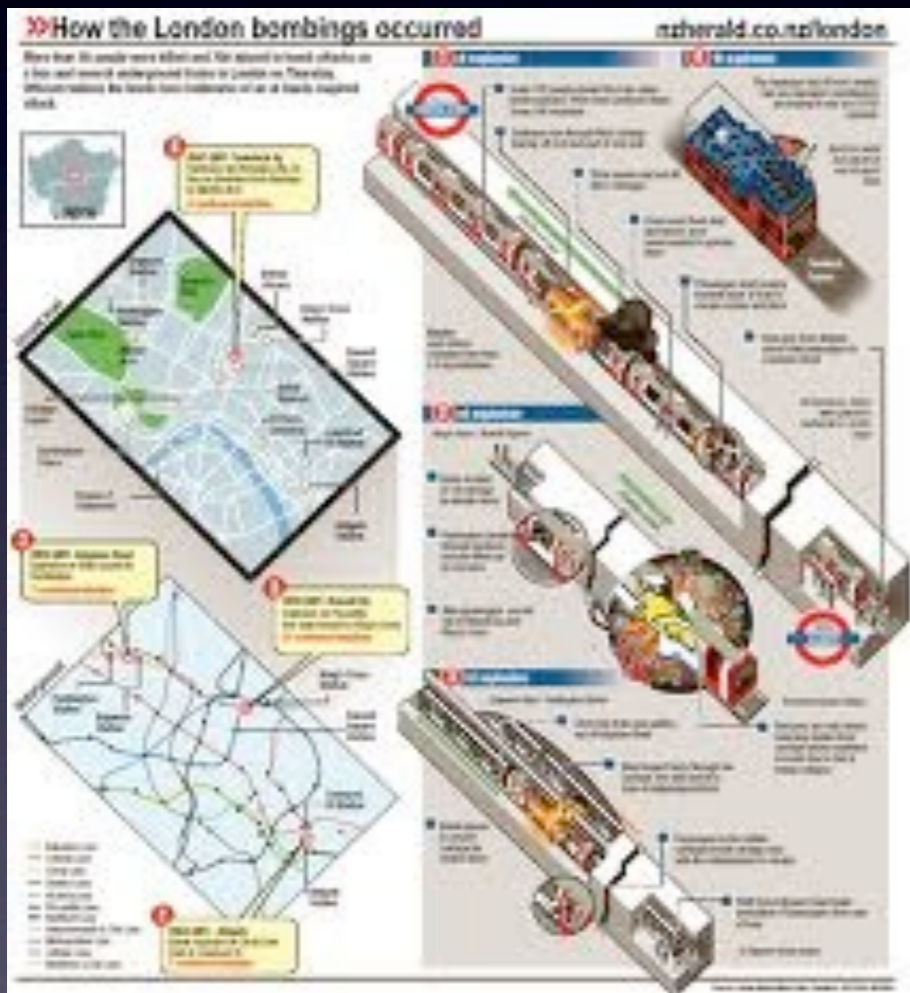


Times of India, Mumbai

Tel Aviv Restaurant 2006



London 7/2005



Madrid 2004

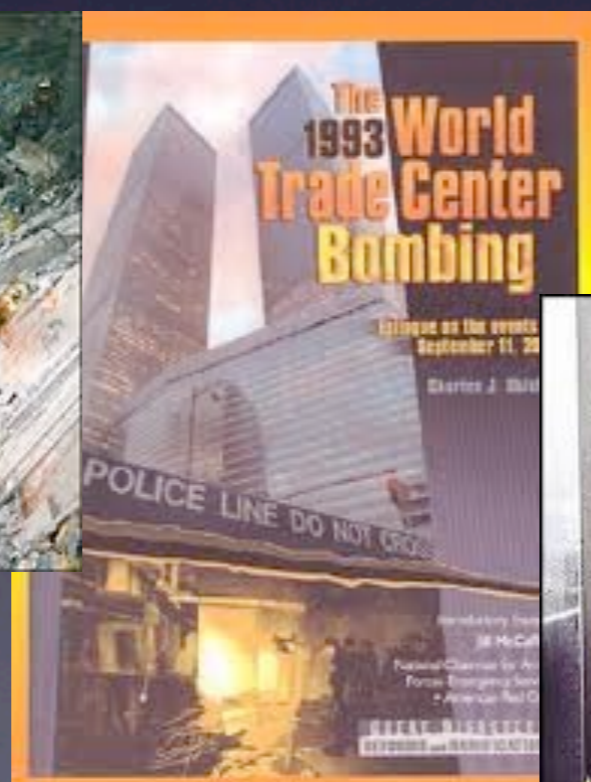


So What?

- Previously a “non-US” problem
- Domestic terrorism
- Now the single greatest terrorist threat on US soil
- Are we ready?

US events

- Murrah federal building (1995)
- Olympic park (1996)
- Abortion clinic (1996)
- First WTC (1993)



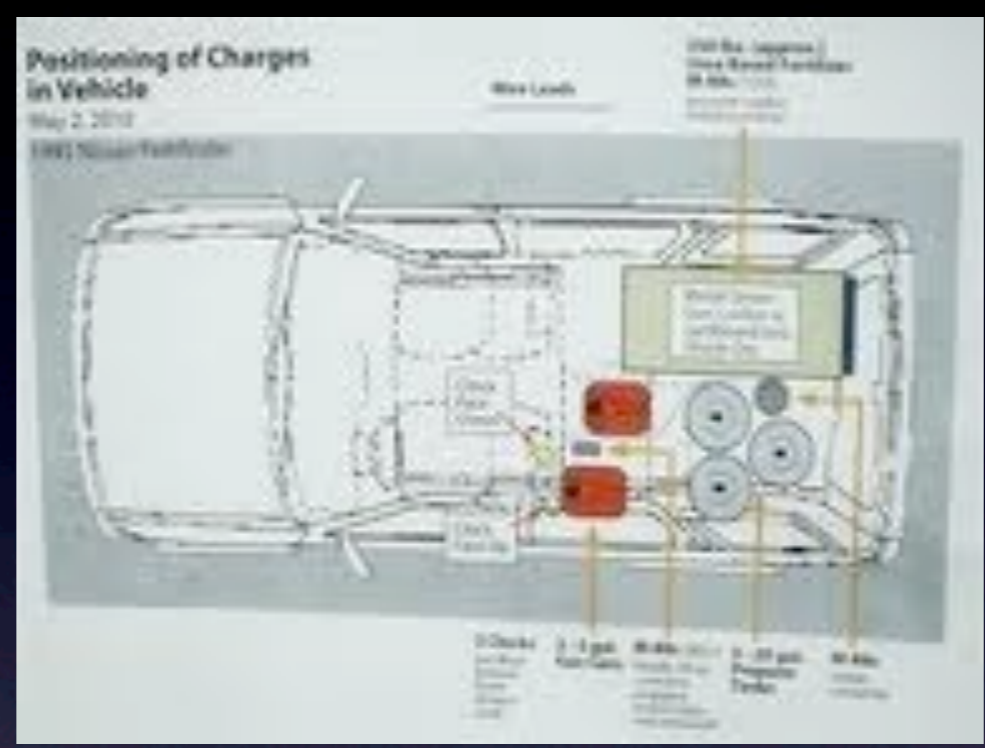
Failed Attempts

- Portland, Oregon - Christmas Tree Lighting
- Times Square Truck Bomb

THE PLACE IN POLITICS **LIVE** msnbc



BREAKING NEWS **AUTHORITIES ARREST SUSPECT IN ATTEMPTED TIMES SQ. CAR BOMBING**



So What? I don't live
near the city, why do I
care?

Non-Terror Events

- Meth lab explosions
- Silo explosions
- House Explosions
- Propane tanks (BBQ, etc.)

Massive Crystal Meth Lab Found in N.Y.

BEEKMANTOWN, N.Y.

Federal and New York authorities said they "methamphetamine in a room at the Stone H

One of the agents investigating the case, Dr NewsChannel 5 that officials just happened t

"Today, we just got lucky -- right place, right significant, no matter the size it is."

MIDDLETOWN JOURNAL

 [Print this page](#)

Firefighter killed in silo explosion on NY farm

The Associated Press

4:26 PM Monday, April 12, 2010

HOUNSFIELD, N.Y. — A fire in an animal-feed silo has triggered an explosion that killed a firefig

Powerful Explosion Levels Long Island House

Updated: Monday, 25 Apr 2011, 8:51 AM EDT
Published : Monday, 25 Apr 2011, 8:51 AM EDT

MYFOXNY.COM STAFF REPORT

BRENTWOOD, N.Y. - A powerful explosion destroyed a vacant house on Long Island and damaged several others.

The explosion left several families in the neighborhood waiting to find out if their homes are safe enough to sleep in after debris was sent flying in all directions.

The blast, that took place in Brentwood, was so powerful it could be felt several miles away.

Types of Blast Devices

- Improvised Explosive Devices (IEDs)
 - Car and truck bombs (OKC, WTC I, TS)
 - Letter / Parcel (Unabomber)
 - Pipe bombs (Olympic park)
 - Backpack / Satchel (Israel / London)
- Incendiary Bombs
 - Airplane bombs (WTC II, Pentagon)
- Rocket Propelled Grenades (RPG)
- Surface to Air Missiles (SAMs)
- Enhanced blast devices (dirty bomb)

IEDs

- Any non-military manufactured explosive device
- Improvised / “homemade”
- Usually made from explosives, commercial blasting supplies, or fertilizer and household ingredients
- Designed to cause injury and death
- Often packed with metal objects like nails or ball bearings; May be “dirty”

Agents

- High-order: HE
- Nitroglycerine (NTG)
- Dynamite
- Plastic (C4)
- TNT
- Ammonium Nitrate / fuel oil (ANFO)
- Low-order: LE
- Petroleum products (“Molotov cocktail”)
- Gunpowder (“black” powder)
- Can become HE, if contained (pipe bomb)

Explosion Scene

- Incident Command
 - crime scene - Jurisdiction?
- Scene Safety
 - Dirty bomb, secondary device, building collapse, dust, fragments, etc.

Crime Scene

- Indicators for crime scene
- Chain of custody
- Avoid disturbing or compromising evidence
- Detection of suspects
- Quick identification and note taking
- Document statements

Common Hazards

- Secondary devices
- Shrapnel
- Collapse
- Contaminant (airborne, patient)
- Perpetrator
- Terrorist patients

Hazards (cont.)

- Uninjured “victims”
- Vehicles out of place or undamaged
- People acting oddly
- Packages or containers at scene

Common Principles

- Contain the incident
- Contain the people
- Protect yourself first, patients second
- Activate ICS
- Decon? Set up zones



Triage

- Unique patterns, multiple and occult injury
- Death often result of multidimensional injury (blast, ballistic, thermal)
- Walking wounded (can you hear me now?)
- Hidden, internal injury

Triage

- Large number of patients may make rapid triage impossible
- Up to 75% will self-refer to local hospitals
- Surge capacity?
- Dynamic process

Blast Injuries

Unique Issues

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

Physics

- Rapid chemical conversion of a solid or liquid into highly pressurized gases
- Gases expand rapidly and compress the surrounding air
- Pressure wave and blast wind are generated and spread in all directions
- Is affected by the medium through which it travels, i.e., air vs. water

Physics

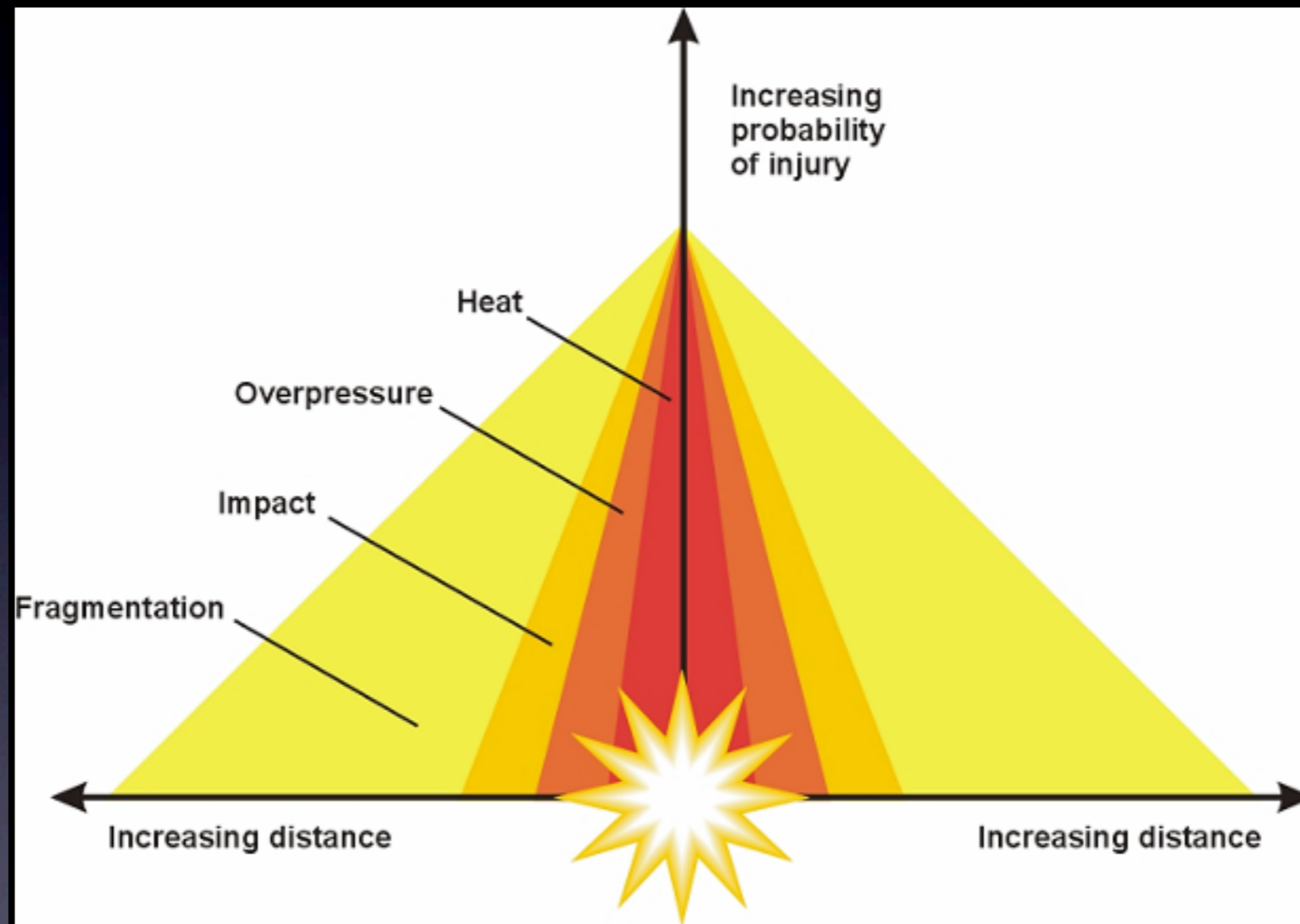
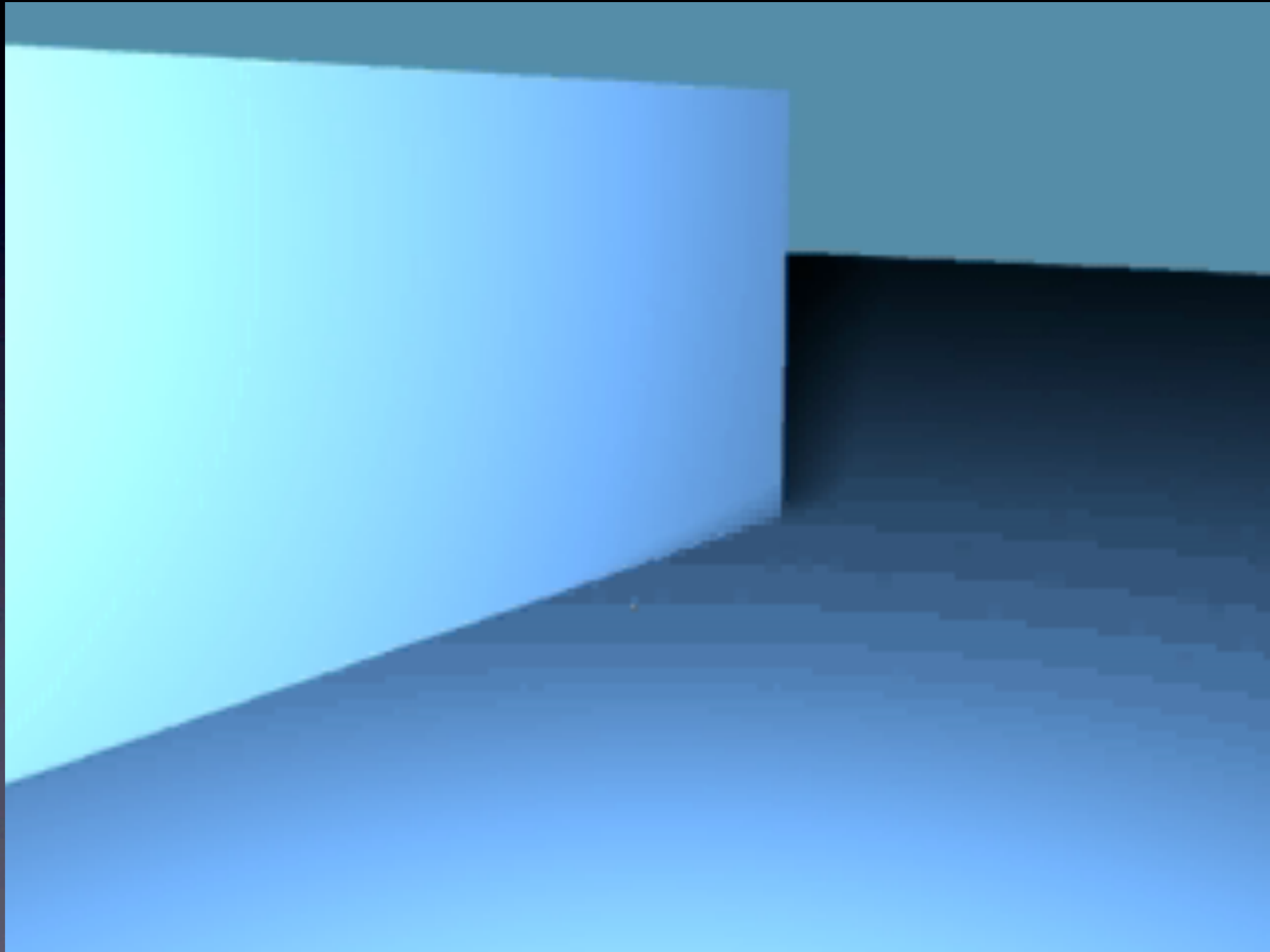


Diagram used with permission of John-Phillipe Dionne. PhD

Blast Physics



Blast Physics



Directionality

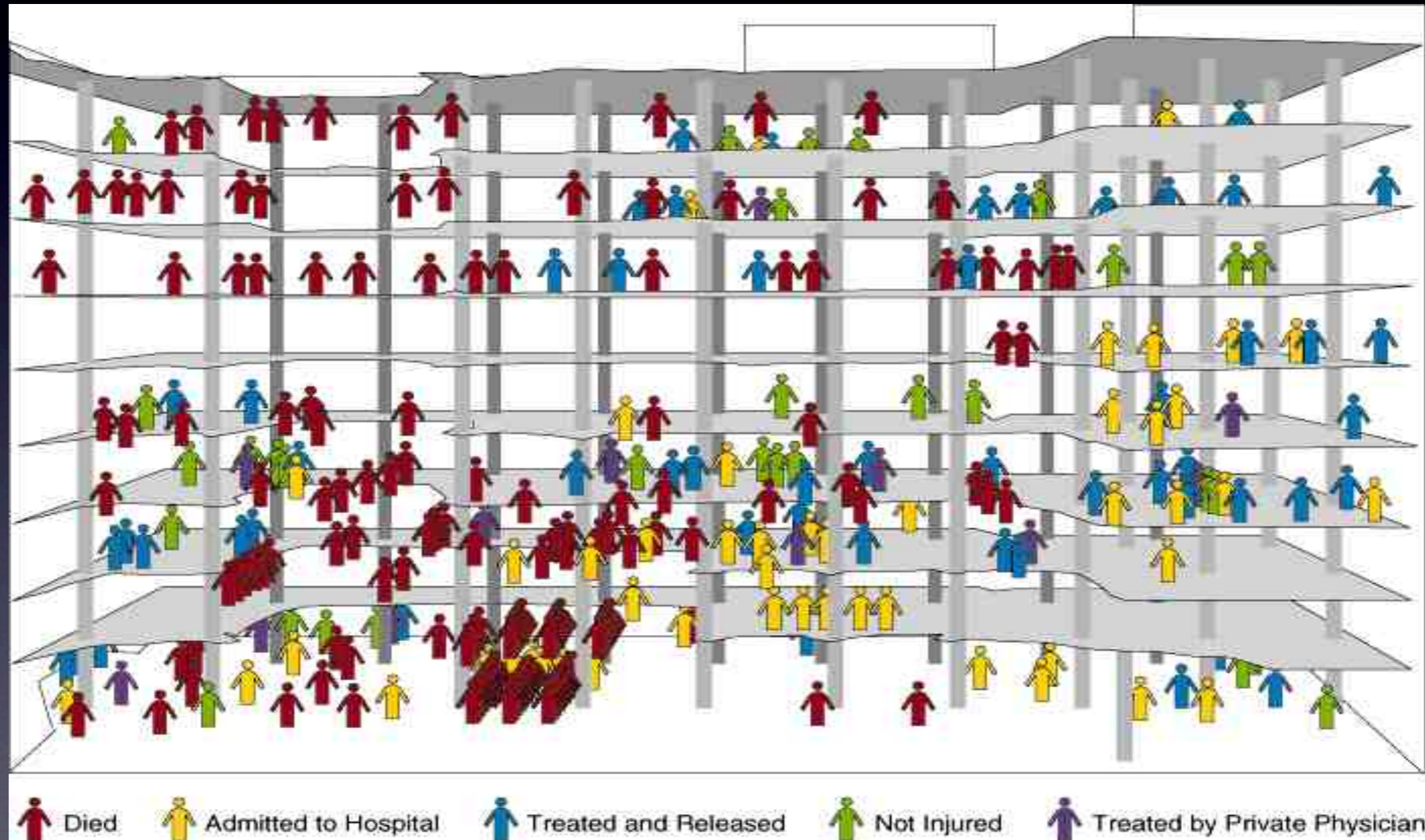
Murrah Building



Photo Courtesy of the City Of Oklahoma City

Injury Pattern

Oklahoma City (1993) – distribution of injuries



JAMA, August 1996, 276 (5): 382-387
© 1996 American Medical Association

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

Pathophysiology

Proposed mechanisms

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

Pathophysiology

- Shearing
 - Caused by tissues of different densities moving at different speeds → visceral tearing
- Irreversible Work*
 - Caused by forces exceeding the tensile strength of the tissue

Categories

- Primary
 - caused by blast wave - over pressure
- Secondary
 - caused by flying debris - shrapnel wounds
- Tertiary
 - Caused by blast wind - forceful impact
- Quaternary
 - Caused by other vectors - heat, radiation

Primary Injury

- Blunt trauma from over pressure wave
 - Unique to high-order explosives
 - Results from the impact of the over-pressurization wave with body surface
 - Blunt force injuries
 - produces barotrauma

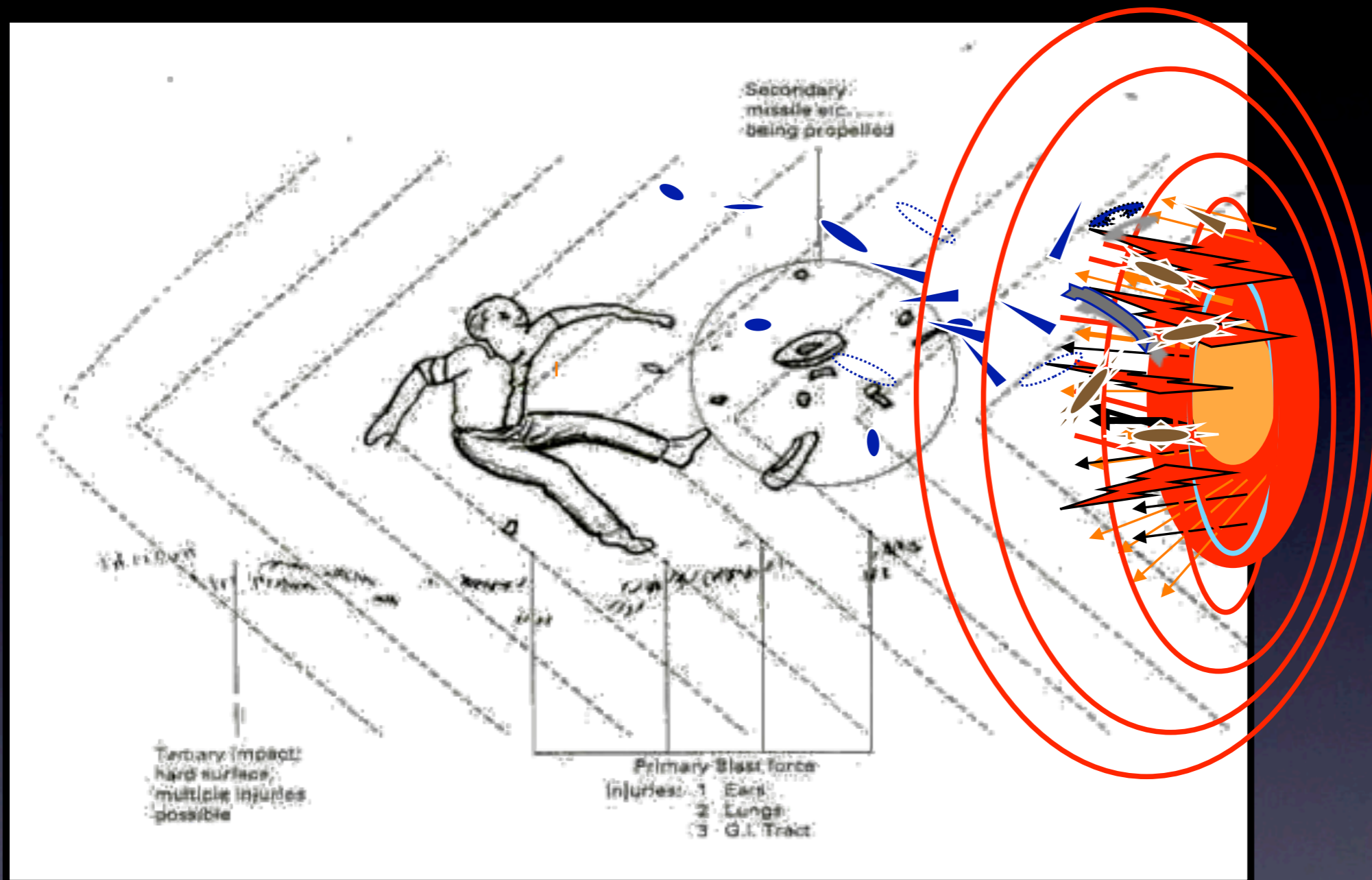


Diagram used with permission of LTC John McManus, Jr., MD, FACEP

Secondary

- The most common cause of death in a blast event is secondary blast injuries. These injuries are caused by flying debris generated by the explosion. Terrorists often add screws, nails, and other sharp objects to bombs to increase injuries.

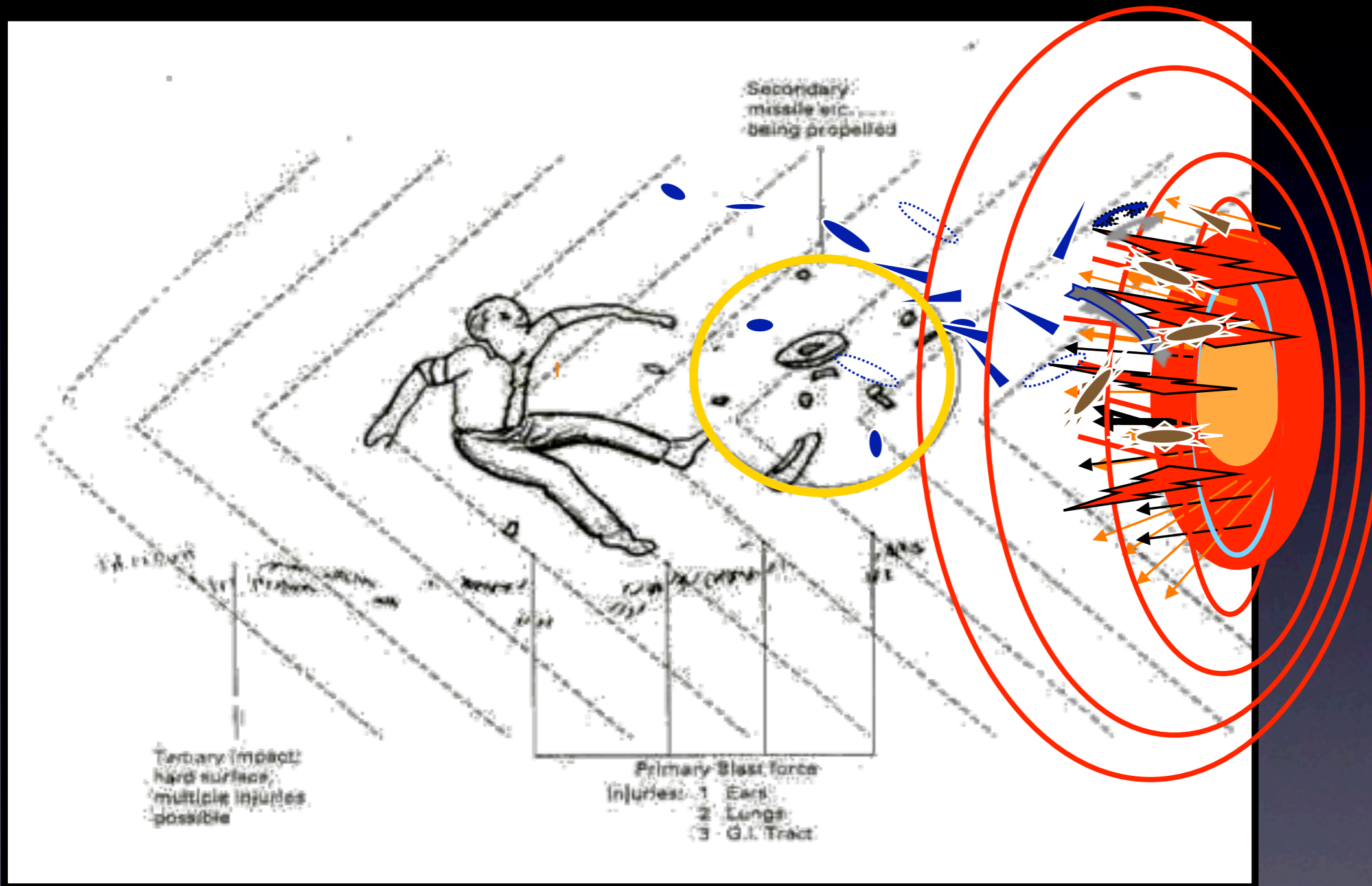


Diagram used with permission of LTC John McManus, Jr., MD, FACEP

Secondary

- The most common types of secondary blast injuries are:
 - trauma to the head, neck, chest, abdomen, and extremities in the form of blunt and penetrating trauma
 - fractures
 - traumatic amputations
 - soft tissue injuries

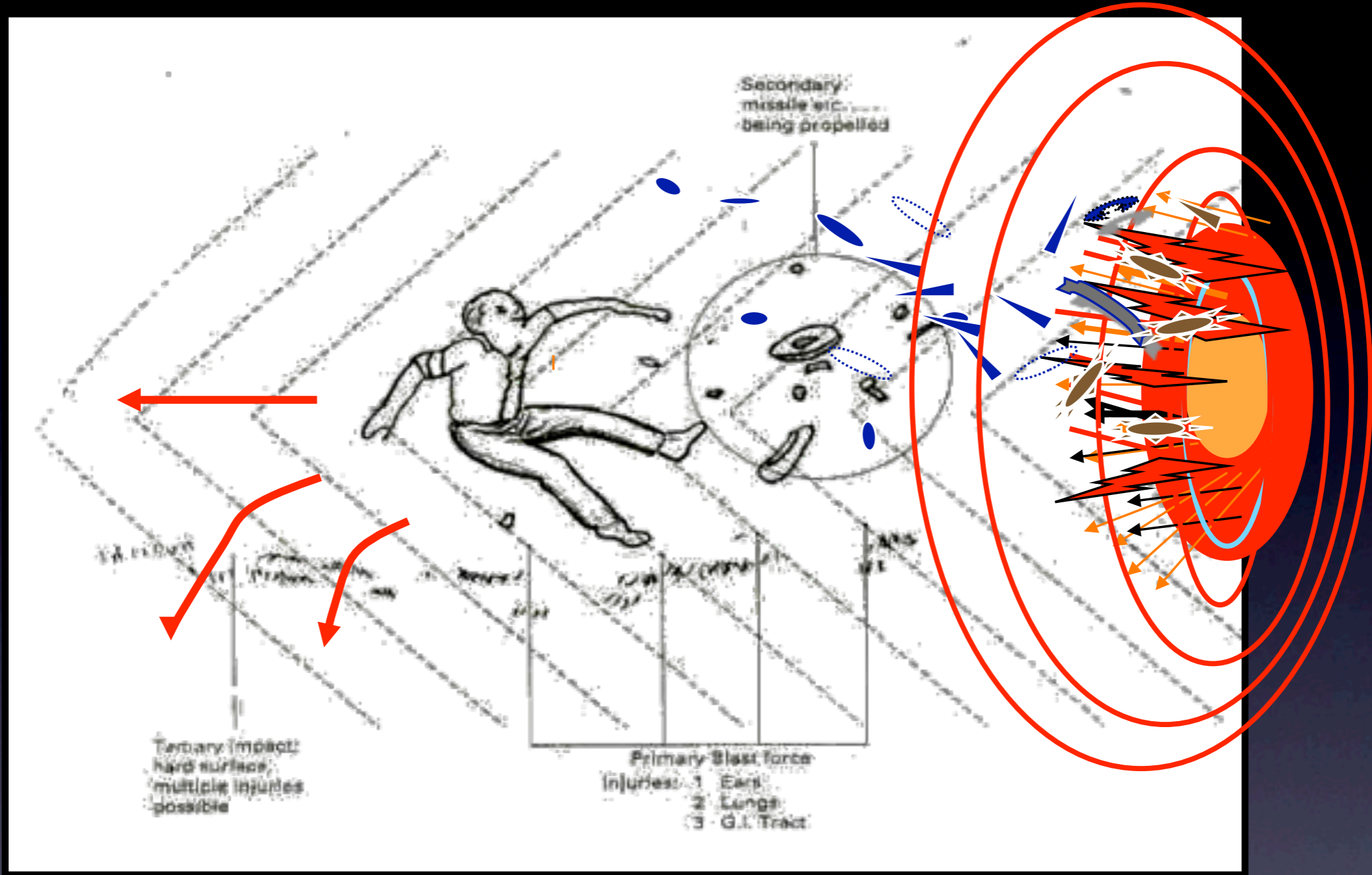
Secondary

- Penetrating trauma (shrapnel wounds)
 - Foreign bodies take unpredictable path through body
 - External signs may be mild
 - Must have a low threshold for imaging (x-ray, CT)
 - Consider all wounds contaminated



Tertiary

- Tertiary injuries are the result of being thrown by the blast wind
- The most common types of tertiary injuries are:
 - head injury
 - skull fracture
 - long bone fracture
- Treatment for most tertiary injury is standard



Quaternary

- All explosion-related injuries, illnesses, or diseases not due to primary, secondary, or tertiary mechanisms are considered quaternary blast injuries. This includes exacerbation or complications of existing conditions.

Quaternary

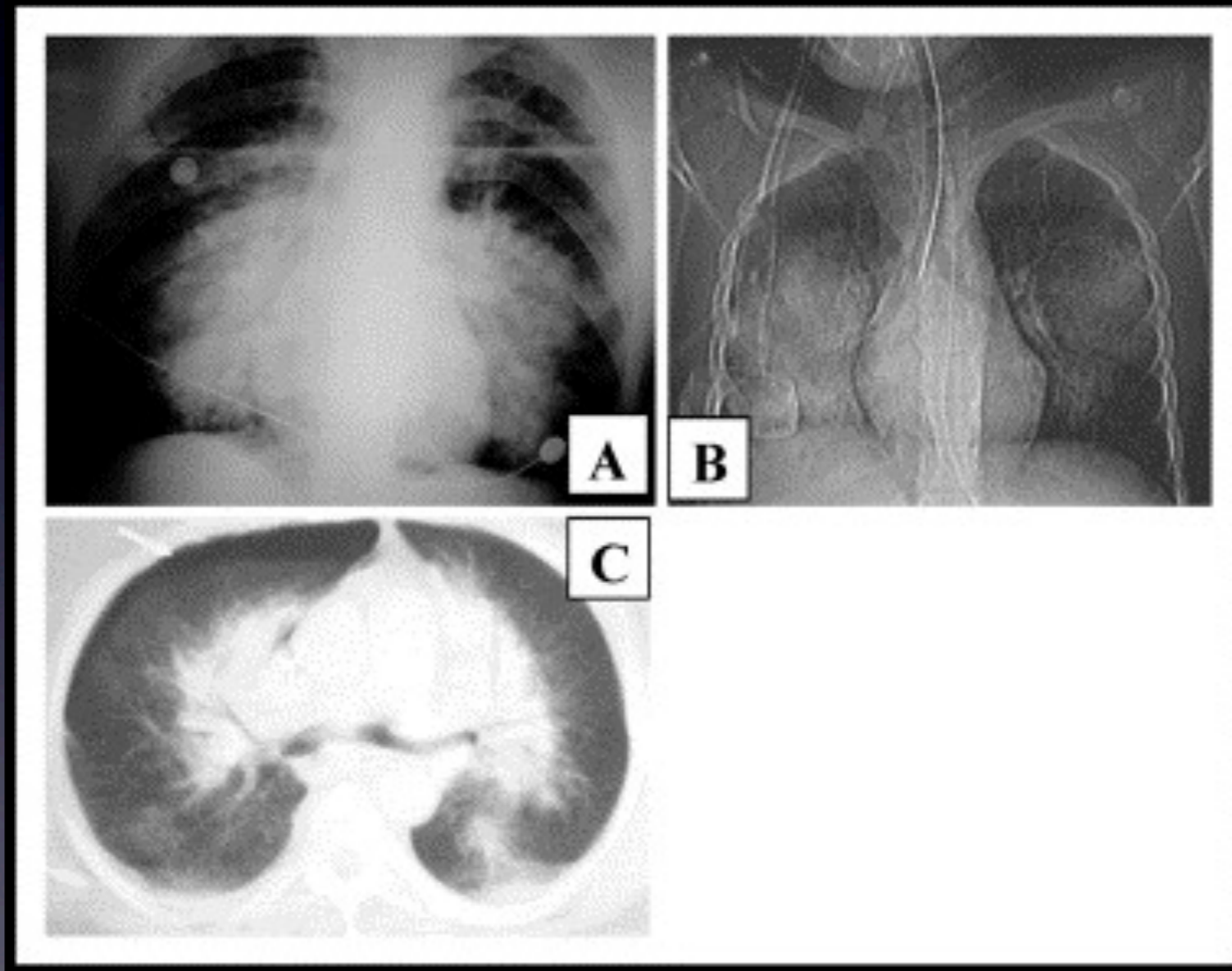
- The most common quaternary blast injuries include:
 - Burns
 - Asthma
 - COPD
 - Other respiratory problems
 - Angina
 - Hyperglycemia
 - Hypertension
 - Crush injury

Blast Lung



CHEST, December 1999; 116(6): 1683-1688

Blast Lung



American Journal of Surgery, V190: 945-950,
Avidan V et al: Blast Lung Surgery

Clinical Manifestations

- Tachypnea
- Hypoxia
- Cyanosis
- Apnea
- Wheezing
- Decreased breath sounds
- Hemoptysis
- Cough
- Chest pain
- Dyspnea

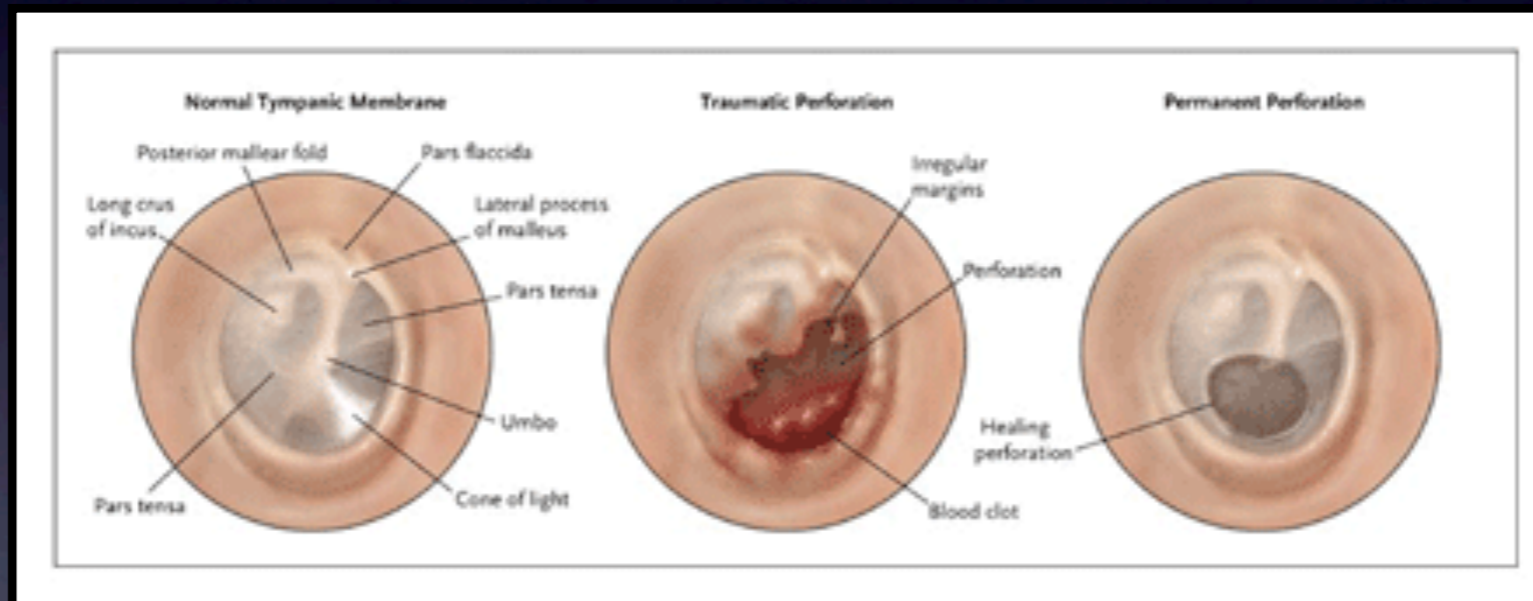
Treatment

- High flow oxygen sufficient to prevent hypoxemia via NRBFM
- CPAP
- Judicious fluid administration (similar to that of pulmonary contusion)

TM Rupture

- Tympanic membrane rupture indicates exposure to an over pressurization wave. It may be found in victims with severe pulmonary, intestinal, or other injuries, or it may be found in isolation. Its presence does not indicate that more sinister blast injuries exist.

TM Rupture



Blast Ear

- Ear injuries may include not only TM rupture, but also ossicular disruption, cochlear damage, and foreign bodies.

Blast Abdomen

- Abdominal injuries (also called blast abdomen) include abdominal hemorrhage and abdominal organ perforation
- Hollow organs most susceptible to over-pressure wave
- Difficult to detect
- May be delayed in onset of symptoms

Blast Abdomen

Clinical manifestations include:

Abdominal or testicular pain

Tenesmus

Rectal bleeding

Solid organ lacerations

Rebound tenderness

Guarding

Absent bowel sounds

Signs of hypovolemia

Nausea

Vomiting

Blast Brain

- Primary blast waves can cause concussions or mild traumatic brain injuries (MTBI) **WITHOUT** a direct blow to the head

Blast Brain

- Consider the proximity of the victim to the blast particularly when given complaints of:
 - Loss of consciousness (LOC)
 - Headache
 - Fatigue
 - Poor concentration, lethargy, amnesia, or other constitutional symptoms
 - Symptoms of concussion and post traumatic stress disorder (PTSD) can be similar

Combined Injuries

- Combined injuries, especially blast and burn injury or blast and crush injury, are common during an explosive event.

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

Your Next Call



Typical Confined Space (e.g., bus or subway car)

- 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

Military Experience



Death Rates After Wounding

- Revolutionary War 42%
- WWII 30
- Korean War ~25
- Vietnam War ~25
- Persian Gulf War ~25
- Global War on Terror (GWOT) <10

Advances from GWOT

- Expanded Damage Control Surgery
- Resuscitative techniques
- Tourniquets
- Hemostatic agents and dressings

Special Considerations

- Pregnancy
- Children
- Elderly
- Disabled
- Language barriers

Pregnancy

- Injuries to the placenta are possible and must be detected
- Second and third trimester of pregnancy need admission for continuous fetal monitoring
- The placental attachment is at risk for primary blast injury
- Screening test for fetal-maternal hemorrhage in second or third trimester

Children

- History of event or patients complaint may be difficult to obtain
- Pulmonary contusion is one of the most common injuries from blunt thoracic trauma. The injury may not be clinically apparent initially and should be suspected when abrasions, contusions, or rib fractures are present.
- CXR is essential
- Specialized equipment
- Identification of regional pediatric trauma centers

Elderly

- May be at a higher risk of mortality and the in-hospital stay may be longer and more complicated
- Orthopedic injuries may be more prevalent
- Blunt chest trauma should be of special consideration
- Decontamination methods may need modification due to limited mobility
- Technical decontamination of medical equipment such as wheelchairs, walkers and other walking aides may be needed

Disabled

- Consideration should be given to patients with underlying medical conditions
- Untreated or inadequately treated fractures may lead to severe and long lasting disabilities

Language Barriers

- Diverse population speaking multiple languages may be an unforeseen obstacle
- Interaction with the deaf, hard of hearing, and the deaf-blind
- History of the event may be difficult to obtain as well as the individual history for the patient
- Translation

Psychological Issues

Sequelae from an explosive event

- Anger
- Frustration
- Helplessness
- Desire to seek revenge

Events affect mental health

- Little or no warning
- Unknown duration of event
- Potential threat to personal safety
- Unknown health risks

Tips for Responders

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

Summary

- Background
- Reviewed recent events
- Blast injury
 - types
 - injury patterns
 - treatments
- Special Considerations



Questions?