Preparation for *Homeland Defense*

Terrorism and Terrorist Homicide Bombings

Pre-Hospital preparation For Effects of Explosive Blast injuries

Crabtree, James *Terrorist Homicide Bombings: A Primer for Preparation.* Journal of Burn Care & Research. 27(5):576-588, September/October 2006.

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Terrorism: Introduction and Awareness

Terrorism Defined:

"Terrorism is the unlawful use of force or violence against persons or property to intimidate or coerce a government or civilian population in the furtherance of political or social objectives"

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Why Use Terrorist Tactics?

To attract attention to a cause

- Passive-aggressive type behavior
  - Confront easy targets
  - Avoid difficult targets
- To instill fear
- To upset confidence in a government
- To keep people from functioning in society

Nothing is 'off limits'

- No rules of engagement
- Nobody is 'innocent'

Women and children are considered legitimate targets

Terrorism: Introduction and Awareness

- Differences between terrorism and criminal acts
  - Terrorism does not result in traditional criminal gains
  - Reason for the attack are not obvious
    - Event will appear "senseless"
  - Terrorism creates widespread psychological impacts
  - Multiple attacks can occur simultaneously
  - A goal may be to cause harm to rescuers
    - The attack & violence is brought to the hospital
  - Medical response activities can be complicated by;
    - Mass casualties
    - Crime scene considerations
    - Hazardous materials

Terrorism: Introduction and Awareness

Similarities between terrorist and criminal events

- Need for excellent cooperation between Medicine and Law Enforcement
  - Evidence collection and preservation
    - Problems handling and releasing personal effects of victims
  - Collection of statements from witnesses
    - Some statements may necessarily be 'dying declarations'
    - Statements may be 'intelligence' instead of 'evidence'

Terrorism: Introduction and Awareness

- **Attributes that might predict an attack or location**
  - Crowded area
  - Easy public assess with little or no security
  - Politically sensitive or symbolic
  - Anniversary date or major upcoming event
  - Recent threats
  - Location has been attacked previously
- ***Attacks can occur anytime or anywhere***

Terrorism: Introduction and Awareness

- Reasons a terrorist might use NBC weapons
  - Availability – 'recipes' on internet
  - Escape security checks – not metallic
  - Produce mass casualties
  - Attracts attention and produces widespread fear

Terrorism: Introduction and Awareness

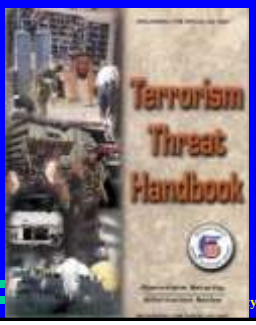
How would the toxic agents (N, B, or C) most likely be weaponized?

- Releasing the toxin as an airborne mist, vapor or spray
- It is unlikely that terrorist toxins would be put into food, water or directly injected

'Weaponization' guides the study of toxic agents and their mitigation

Terrorism: Introduction and Awareness

- Observations that a 'routine emergency' is actually a terrorist release of hazardous materials
  - Emergency takes place away from 'home'
  - Large number of people with similar complaints
  - The 'disease' or symptoms are spreading quickly or seem 'contagious'
  - Situation is preceded by explosion or airborne substance release
  - No easy explanation for symptoms or complaints



Terrorism: Introduction and Awareness

- "Emergency" Decontamination defined
  - Physical removal of harmful substances
  - Performed on living victims
    - Water only or Soap and water
    - Mild scrubbing or washing
  - Performed as soon as possible after exposure
    - At scene and before transport
    - At ED door BEFORE entry to hospital building
      - Self transport victims

Terrorism: Introduction and Awareness

- Basic mechanisms of emergency mass causality decontamination
  - Wash with water (soap if available)
  - Monitor for hyper/hypo thermia
    - Attempt to dry victims and provide clothing

Terrorist Homicide Bombings

- The weapon or device most likely to be used by a terrorist:
  - Traditional bomb or explosive material not contaminated with hazardous material

NOT part of this presentation:

Accidental blasts

- Industrial activities
  - Natural gas
- Motor Vehicle Accidents

Intentional blasts

- Mining
- Overt Military Activities
  - Land mines
- Letter bombs

Historical Precedents

- 1995 Oklahoma City
  - Alfred P Murrah Federal Building
  - 167 dead 509 injured

Historical Precedents

Guilty 2005

- **Eric Robert Rudolph 1995 - 1996**
  - **1996 Olympic Centennial Park**
  - **Otherside (Gay) nightclub**
  - **Women's health centers**
  - ***4 Life sentences w/o parole***

Amateur video shows explosion (889K QuickTime movie)

The second explosion (Courtesy WAGA)

Historical Precedents

- **1993 World Trade Center**
  - **6 dead 1000+ injured**

Historical Precedents

- **1963 16th St. Baptist Church Birmingham, Al**
  4 dead - 22 injured

Historical Precedents

- **1910 Los Angeles Times Building**
  - **20 dead 30+ injured**

Current World Experience

USA 2009 - 939 detonations

14 killed - 135 injured

Main targets – private residences (40%) vehicles (12%) mailboxes (10%)

Motivations – vandalism or experimentation (57%)

ATF - National Bomb Data Center

Terrorist Bomb Designs

- Vehicle / Car bombs
- Package Bombs
- Suicide Bombs

Vehicle / Car Bombs

- Hundreds to thousands of pounds of explosives
- Disguised in normal traffic

Vehicle / Car Bombs

- Prevention includes
  - Security checkpoints
    - Vehicle identification / verification
    - Vehicle weighing
    - Visual inspections
  - Keeping all vehicles away from buildings
    - Concrete barriers (decorative planters, street closures)
    - Indirect approach 'mazes'

Vehicle / Car Bombs

Keeping all vehicles away from buildings;

- **Evacuation distances**

1/3 mile

½ mile

¾ mile

ATF	VEHICLE DESCRIPTION	MAXIMUM EXPLOSIVES CAPACITY	LETHAL AIR BLAST RANGE	MINIMUM EVACUATION DISTANCE	FALLING GLASS HAZARD
	COMPACT SEDAN	500 Pounds 227 Kilos (In Trunk)	100 Feet 30 Meters	[illegible] 457 Meters	1,250 Feet 381 Meters
	FULL SIZE SEDAN	1,000 Pounds 455 Kilos (In Trunk)	125 Feet 38 Meters	1,750 Feet 534 Meters	1,750 Feet 534 Meters
	PASSENGER VAN OR CARGO VAN	4,000 Pounds 1,818 Kilos	200 Feet 61 Meters	2,750 Feet 838 Meters	2,750 Feet 838 Meters
	SMALL BOX VAN (14 FT BOX)	10,000 Pounds 4,545 Kilos	300 Feet 91 Meters	3,750 Feet 1,143 Meters	3,750 Feet 1,143 Meters
	BOX VAN OR WATER/FUEL TRUCK	30,000 Pounds 13,636 Kilos	450 Feet 137 Meters	6,500 Feet 1,982 Meters	6,500 Feet 1,982 Meters
	SEMI-TRAILER	60,000 Pounds 27,273 Kilos	600 Feet 183 Meters	7,000 Feet 2,134 Meters	7,000 Feet 2,134 Meters

ATF 5400.1 (01-96)

Package Bombs

- **Explosive material**
- **Shrapnel**
- **Common package**

Women's clinic

Otherside nightclub

Package Bombs

Light enough to carry easily

Common enough to blend in

Centennial park

Package Bombs

- Prevention includes
  - Security checkpoints
    - Personal visual inspections
    - Metal detectors / x-rays
    - Sniffers (dogs or electronic)

  - Report 'suspicious' packages
    - Unattended / unclaimed

Suicide Bombs

- Explosives worn on belt or vest
- Significant Shrapnel
- Arms raised to maximize damage

Suicide Bombers

- Bombers are not 'crazy'
  - Deeply committed to cause
  - Educated, sophisticated, have families
  - Religious beliefs adapted to allow suicide
- Bombers do not act alone
  - Bombers supported by organization
    - Bomb builders
    - Psychological training & preparation
  - Targets chosen, planned & practiced
- Suicide by proxy
  - Sinn-Fein/IRA

Suicide Bombers

- Why Suicide?
- *Prevention is difficult to impossible !*
  - Intelligence of impending attack
  - Security check points
    - bulky inappropriate clothing

- Forcing the bomber to detonate away from people
- Terrorists can change targets at the last minute
  - Crude guided missile
- *Suicide Bombers = only 0.6% of all attacks . . .*
  . . . but 66% of all fatalities!

Israeli Security Agency (2004)

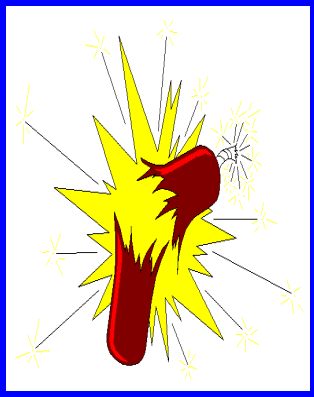
NO SECURITY SYSTEM IS IMPENETRABLE IF THE BOMBER HAS A SUICIDAL INTENT

Blast Mechanics

- Three types of explosions
  - Mechanical
    - Compressed gas cylinders
  - Nuclear
    - Sustained atomic reaction
  - Chemical
    - Small amount of solid or liquid material converted into a very large amount of gas in a very short time.

Blast Mechanics

- Explosive Blasts are essential to our society:
  - Automobile engines
  - Mining & earth moving
  - Bonding dissimilar metals
    - Sandwiched copper in Quarters
  - Aircraft construction
    - Explosive rivets
  - Throwing life lines between boats
  - Preventing avalanches



Blast Mechanics

- Blast Overpressure
- Blast winds
- Burns

Blast Mechanics
Blast Overpressure

- Expanding gases force out in all directions
  - Subsonic or supersonic speeds
    - not important to medical providers
  - Objects can be thrown at 2000 mph

Blast Mechanics
Blast Overpressure

- Only chemicals are destroyed / incinerated
  - Bomb pieces are bent/twisted but remain intact
  - Important for evidence
- Instantaneous increase in "Atmospheric Pressure"
  - Followed by instantaneous 'vacuum'
  - Immediate return to normal pressure

Blast Mechanics
Blast Overpressure

- Increase in 'Atmospheric Pressure'
  - 0.3 - 0.7 psi - drywall blown from studs
  - 0.3 - 1.0 psi - glass windows blown out
  - 6 - 8 psi - vehicles are overturned

Blast Mechanics
Blast Overpressure

Increase in 'Atmospheric Pressure'

Blast Mechanics
Blast Overpressure

Increase in 'Atmospheric Pressure'

Blast Mechanics
Blast Winds

- **Ever expanding air mass makes its own wind**
  - 1500 mph after a 100 psi overpressure
  - – Objects are blown into people
  - – People are thrown against objects

Blast Mechanics
Blast Winds

Objects are blown into people
People are thrown against objects

Blast Mechanics
Blast Winds

Objects are blown into people
People are thrown against objects

Blast Mechanics
Blast Winds

Objects are blown into people

People are thrown against objects

Boston Marathon 4/15/2013

Blast Mechanics
Blast Winds

Blast forces do not automatically start fires

Fire suppression materials rarely seen

Water, dry powder etc.

Blast Mechanics
Blast Winds

Blast forces do not automatically start fires

Moscow Subway 3/29/2010

Blast Mechanics
Blast Winds

Blast scenes are rarely charred

Blast Mechanics
Thermal Burns

- Burns?
- High temps in expanding gas cloud
  - Lasts only a very short time
- Critical Burn injuries are rare
  - More common among the dead
  - Few victims admitted to burn centers
- UNLESS A SUBSEQUENT FIRE !

Bali was a Conflagration

- 2 Car Bombs - Crowded Nightclubs
- Scene quickly became an inferno *Reasons Unknown*
- NOT TYPICAL!

Blast Mechanics
Thermal Burns

Flash Burns from explosions

- **Large body surface area**
- **Shallow depth**

(Leibovici 1996)

Moscow Subway 2/6/2004

Blast Mechanics
Thermal Burns

Flash Burns:

- **Large body surface area**
- **Shallow depth**

Blast Mechanics
Thermal Burns

Flash Burns - Large body surface area- Shallow depth

Blast Mechanics
Thermal Burns

Flash Burns : Singed hair - Smoke exposure

Moscow Subway 3/29/2010

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Blast Mechanics
Thermal Burns

Flash Burns : Singed hair - Smoke exposure

London 7/7/2005

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Blast Mechanics
Thermal Burns

- Few victims admitted to burn centers
- Little skin grafting needed

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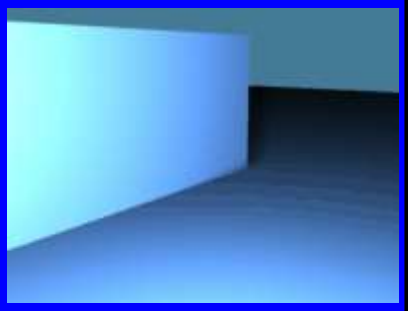
Blast Mechanics
Mechanisms of Injury

Blast casualties are affected by:

- Open air or closed room
  - Distance from the blast
  - Size of room
  - Height of ceiling



- Was there a building collapse?
- Number of persons in the area
- Was shrapnel used?
- Was there a resultant fire?

Leibovici et al 1996, Saravanapavananthan 1978, Stein 1999, Greenberg 1998, Mellor 1989, Pyper 1983, Hayden 1978, Quintana 1997

Blast Mechanics
Mechanisms of Injury

The number of killed & wounded is more related to the type of attack than the amount & type of explosives

Blast Pathophysiology

Blast overpressure

- *Air filled organs most vulnerable*
  - **Lungs** (injury threshold – 4.2 psi)
  - Alveoli can compress – fluid filled capillaries can not
  - Torn capillary membranes
    - Pulmonary contusion
    - 'Blast Lung'
  - Pneumo-thorax if air escapes into pleura

Blast Pathophysiology

- Blast Lung:
  - Hypoxemia
    - possible hypotension, bradycardia, hemoptysis
  - May take 12-24 hours to develop
- Treat similarly to other hypoxic situations
  - High flow O_2 by mask
  - Consider intubation if severe
  - No diuretics
  - Good long term outcomes without sequela

Death From Blast Lung

- Abu Musab al-Zarqawi
- 2 bombs near safe house
  - Survived ~30 minutes
  - 'Restrained to stretcher'
  - 'Mumbled incoherently'
  - 'Coughed up blood'

Blast Pathophysiology

Blast overpressure

- *Air filled organs are most vulnerable to injury*
  - **Abdomen & GI tract** (injury threshold 6 psi) Yang 1996
- Air is compressed & balloons out in other areas
  - Ruptured intestinal wall
    - Ileo-cecal joint most common to burst Mayorga 1997
  - More common in underwater blasts
    - Possibility must be considered in all situations

Blast Pathophysiology

Blast overpressure

– Abdomen & GI tract:

- As tissue layers are compressed & released;
  - Disrupts epithelial, mucosal, sub-mucosal tissues
    - Resultant hemorrhage, necrosis, possible emboli
  - Symptoms similar to abdominal trauma
  - Challenge in predicting future of lesion
    - Burst or spontaneous recovery?

Blast Pathophysiology

Blast overpressure

Auditory (injury threshold 5 psi)

- Pressures cant equalize quickly enough
  - Ruptured tympanic membranes
    - most heal spontaneously
  - Dislocated/fractured ossicles
- Multiple long term problems
  - Tinititis, vestibular, sensory loss

- Not reliable indicator of concealed injuries!
  - Detailed additional exams recommended

Blast Pathophysiology

Blast overpressure

- Neurological
  - Air emboli may happen
    - Blast bends?
    - Air admitted through damaged lung capillaries?
  - May be a cause of death
  - Not significant pathology in survivors
- Transient flattening of EEG waves in pigs

Blast Pathophysiology

- Blast forces and blast winds
  - Direct tissue trauma
    - Flying objects hitting victims (Shrapnel)
    - Victims hitting other objects (Tertiary contacts)
  - Amputation

Blast Pathophysiology

- Blast forces and winds
  - Flying objects

Blast Pathophysiology

- Blast forces and winds
  - Flying objects
  - Intentional Shrapnel

Blast Pathophysiology

- Intentional Shrapnel
- Ball bearings, nuts, bolts, nails etc.
  - Penetrating injuries similar to multiple small arms fire
  - Hundreds of objects may be seen on x-ray
  - Significant internal injuries
    - Objects may enter brain, spinal column
  - Nails enter head first (unlike bullets)
  - Objects are commonly retained in victims
    - Lifetime impairments
    - Long term disabilities

Blast Pathophysiology

- Blast forces and winds
  - Direct tissue trauma

Blast Pathophysiology

- Blast forces and winds
  - Direct tissue trauma

Blast Pathophysiology

- Blast forces and winds
- Amputations

Blast Pathophysiology

Amputations

- **First: Blast forces shatter bone**
  - Through bending type force
- **Second: Blast winds separate limb**
  - Avulsion type of mechanism
- **Occurs to mainly long bones**
  - Rarely at joints
- **High risk for exsanguination - Rarely re-attachable**
  - Tourniquet
- ***Amputation injuries more common among dead & expectant victims***

Blast Pathophysiology

- **Amputations**
- **Tourniquet may be necessary**

Blast Pathophysiology

Other considerations

- **Pregnancy**
  - **Blast forces disrupt tissue interfaces**
  - **High risk for placental separation**
    - **Fetus not generally harmed**
- **Inhalation injuries**
  - **Smoke**
  - **Dust**
- **Crush syndrome**
    - **Seen in building collapses**

Blast Statistics
Few critical patients

- **Total number of victims:**
  - **Highest number = Minor injuries } 2/3**
  - **Second highest = Fatalities**
  - **Fewest = Critical / Trauma Center patients } 1/3**

The Blast Scene

- **TRIAGE IS NUMBER ONE CONCERN IN DEALING WITH BLAST MANAGEMENT**
  - ***Finding the salvageable among the dead***

Predicting Victims

MOST PATIENTS SUSTAIN MINOR INJURIES

The Blast Scene
Where are the survivors?

Victims leaving bus moments after the blast

London 7/7/2005

13 dead at this scene

Predicting Victims

Injuries predominately to head/neck & periphery

Predicting Victims

Injuries predominately to head/neck & periphery

London 7/7/2005

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Predicting Victims

Injuries predominately to head/neck & periphery

Moscow Subway 3/29/2010

Predicting Victims

Injuries predominately to head/neck & periphery

Boston Marathon 4/15/2013

Predicting Victims

Clothing offers a degree of protection from flying objects

Predicting Victims

- Review of 33 suicidal bombings in Israel
  - Oct 2000 to Aug 2002, involving 6 or more causalities
- Average of 57 victims/incident
  - killed or wounded; range: 6 to 145 victims

Predicting Victims

- Primary blast injury generally results in Death
  - Expect between 3-8 wounded for every dead victim

Scene Operations

- SAFETY! SAFETY! SAFETY!
  - Secondary devices
    - Israelis remove victims quickly
    - Personal effects left at scene

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Scene Operations

- SAFETY! SAFETY! SAFETY!
  - Falling debris
    - Killed Rebecca Anderson Oklahoma City

Management of Blast Situations

- Scene operations
  - Evidence preservation

Management of Blast Situations

- Post Mortem Care - Mass fatality event
  - Identification & notification

Management of Blast Situations

- Triage
- #1 problem in patient management
  - Ongoing & continuous
    - NOT performed just once !
  - Victims need to be re-evaluated & reclassified at hospital

Special considerations

- Blood & body fluid contamination
  - Monitor for seroconversion?
  - Hepatitis vaccinations?
    - Rate 10% Palestinian vs. 1-2% Israelis

    Siegel 2001

- Market place infection
  - Higher incidence of Candida septicemia

  Wolf et al 2000

Special considerations

Blood & body fluid contamination

Special considerations

Additional contamination

- NBC material
  - Radiation detectors?
- Nitrate explosives
  - Ammonium nitrate/Fuel Oil
  - Caused nitroglycerine type effects
- Rat poison (coumarin types)
  - Anecdotal or myth ?
    - Incalculable dose
  - Vitamin K
  - Factor 7 injection

Psychological & Long Term

- **Psychological Trauma to civilians**
  - Sudden death
    - Role changes in family
  - Care of newly handicapped family member

Psychological & Long Term

Psychological Trauma to rescuers

"Rescuers search baby carriages for signs of human remains . . ."

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Psychological & Long Term

Psychological Trauma to rescuers

War wounds inflicted on civilians

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Psychological & Long Term

Psychological Trauma to rescuers

War wounds inflicted on civilians

Psychological & Long Term

Psychological Trauma to rescuers

Cell phones ringing on dead bodies . . .

. . . You know their families are looking for them

"The noise that gives nightmares"

Psychological & Long Term

"Better off Dead" feelings among survivors

Emily Lyons RN
Women's Health Nurse

Psychological & Long Term

- After it is all over…
  . . . trying to achieve closure
- Society's Acknowledgement
  –Monuments and Memorials

Monuments and Memorials

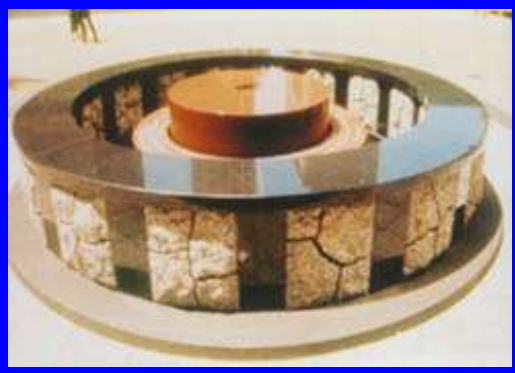
- Oklahoma City

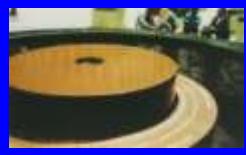
Monuments and Memorials

- Olympic Centennial Park
  - Atlanta, Georgia

Monuments and Memorials

- 1st World Trade Center





Monuments and Memorials

- Los Angeles Times Blast
  - 1910

Monuments and Memorials

Bali's Wall of Names

Monuments and Memorials

- Israeli memorials consist of:
  - Small plaques
  - Impromptu flower & candle displays

Monuments and Memorials

- Israeli memorials <u>Do not honor terrorists</u>
  - Bus stops are operating again hours after a blast
  - Businesses cleaned & reopened within days
- Promote a return to normal life
  "They can't disrupt our Country"
  "Terrorists won't stop our way of life"
- How will the USA react to future attacks?