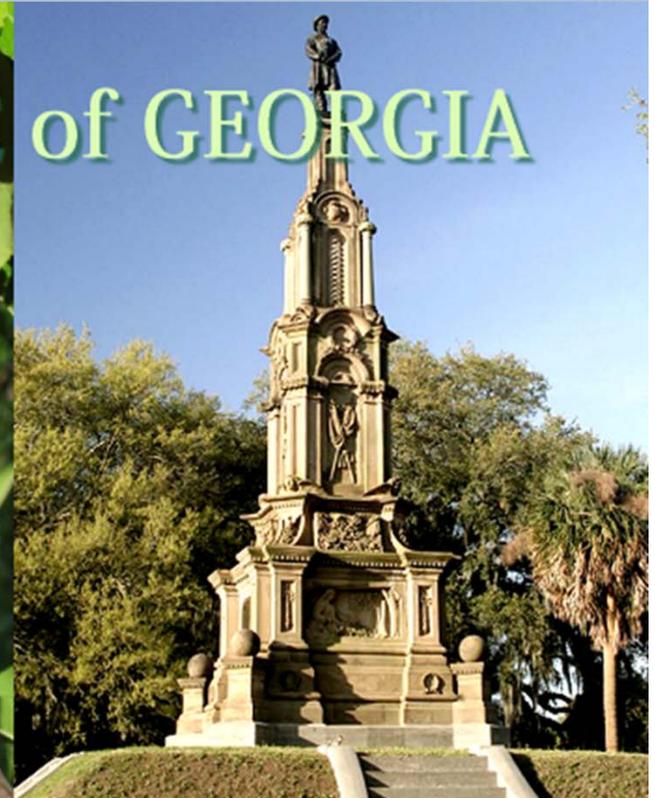


# Blast Injuries

John Devlin, MD, FACEP

GA Poison Center / Emory University /  
Centers for Disease Control and Prevention



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# Image attribution

- All military images / slides borrowed with permission from the USMC RECON Combat Lifesaver Course

# Most CBRNE start with a blast



Col Isaac Ashkenazi

- “If you know how to handling bombing victims, you can handle 70% of all disasters.”



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# HISTORICAL INCIDENTS

# Discovery

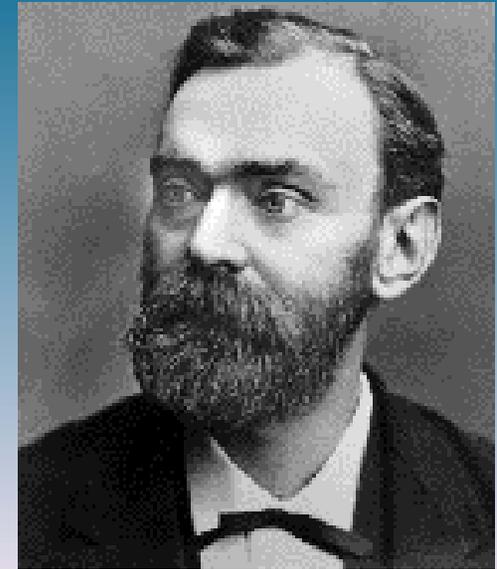
- Believed to be discovered in China in the 10<sup>th</sup> century
- Called black powder or gun powder
  - Charcoal
  - Potassium nitrate
  - Sulfur
- Used for signals and fireworks
- Then used in warfare



A Mongol bomb thrown against a charging Japanese samurai during the Mongol Invasions of Japan, 1281

# Dynamite

- Invented by Alfred Nobel
- Added silica to liquid nitroglycerine making the more malleable dynamite
- Also invented blasting caps that were made with a fuse and gunpowder



# Texas City Disaster 1947

- 7 KiloT of ANFO exploded on board of SS Grandcamp in the port killing 581 people



# Composition C4

- Greater than 90% RDX
- Needs a blasting cap to detonate
- 1.34 as strong as TNT



Inserting Blasting caps into C4



# 1993 – WTC Bombing

*AP/Richard Drew*

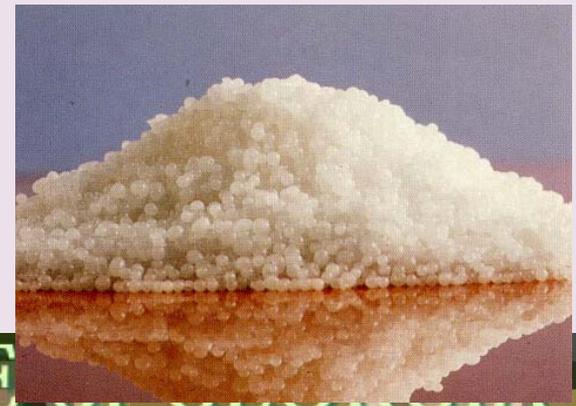


The underground parking garage of the World Trade Center one day after the February 1993 explosion

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# Ammonium Nitrate/Fuel Oil (ANFO)

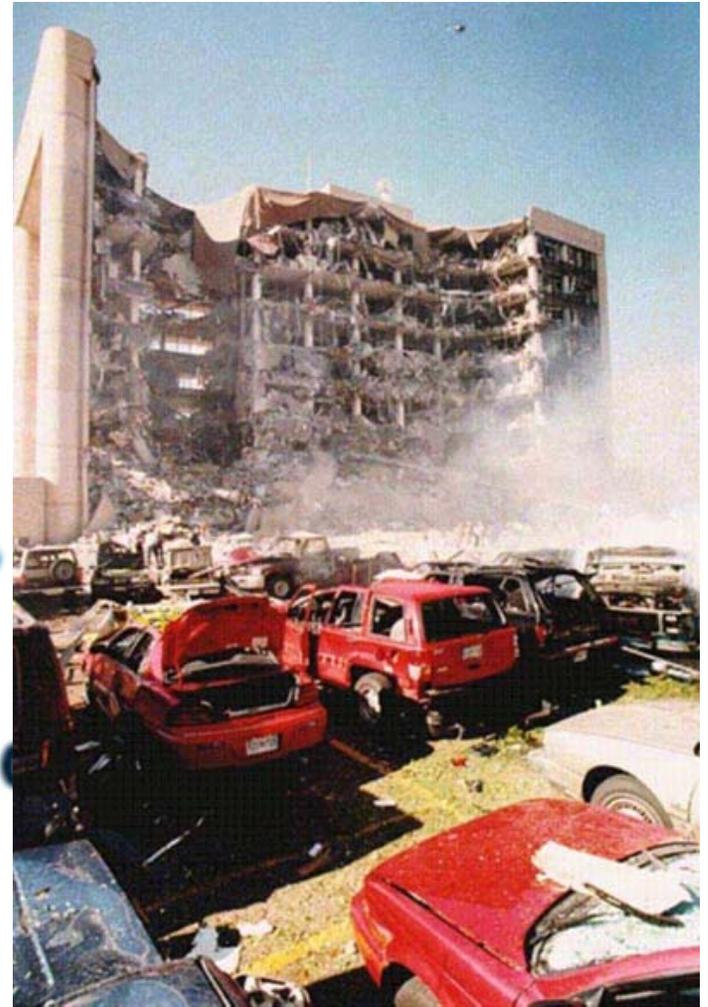
- 80% of explosive used in the USA
- High explosive
  - Requires a booster



STATE

# 1995 - Oklahoma City Bombing

- Ryder truck detonated in front of building at 9:02am (CST)
- Blast destroyed 1/3 of the building, creating a crater that was 30 ft wide and 8 ft deep
- Blast destroyed or damaged 324 buildings within radius of sixteen-blocks, burned 86 cars, and shattered glass in 258 nearby buildings
- 168 confirmed dead

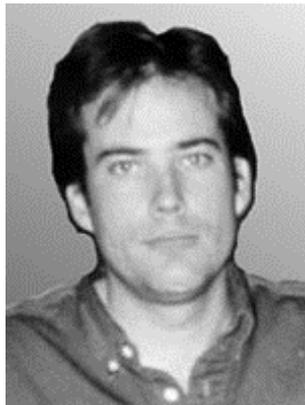


- By the end of the day, 153 victims had been treated at St. Anthony Hospital, eight blocks from the blast, over 70 at Presbyterian, 41 at University, and 18 at Children's



# Birmingham Women Health Center 1998

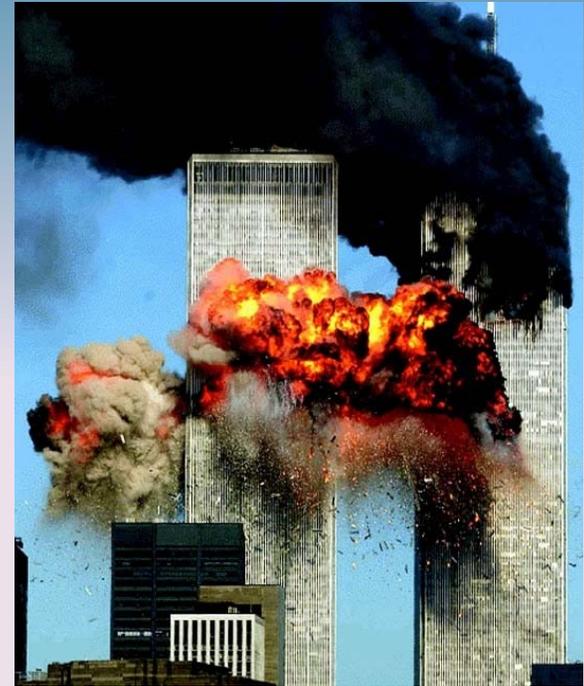
- Eric Robert Rudolph
  - 1996 Olympic Centennial Park
  - Otherside (Gay) nightclub
  - Women's health centers
  - FBI top ten list



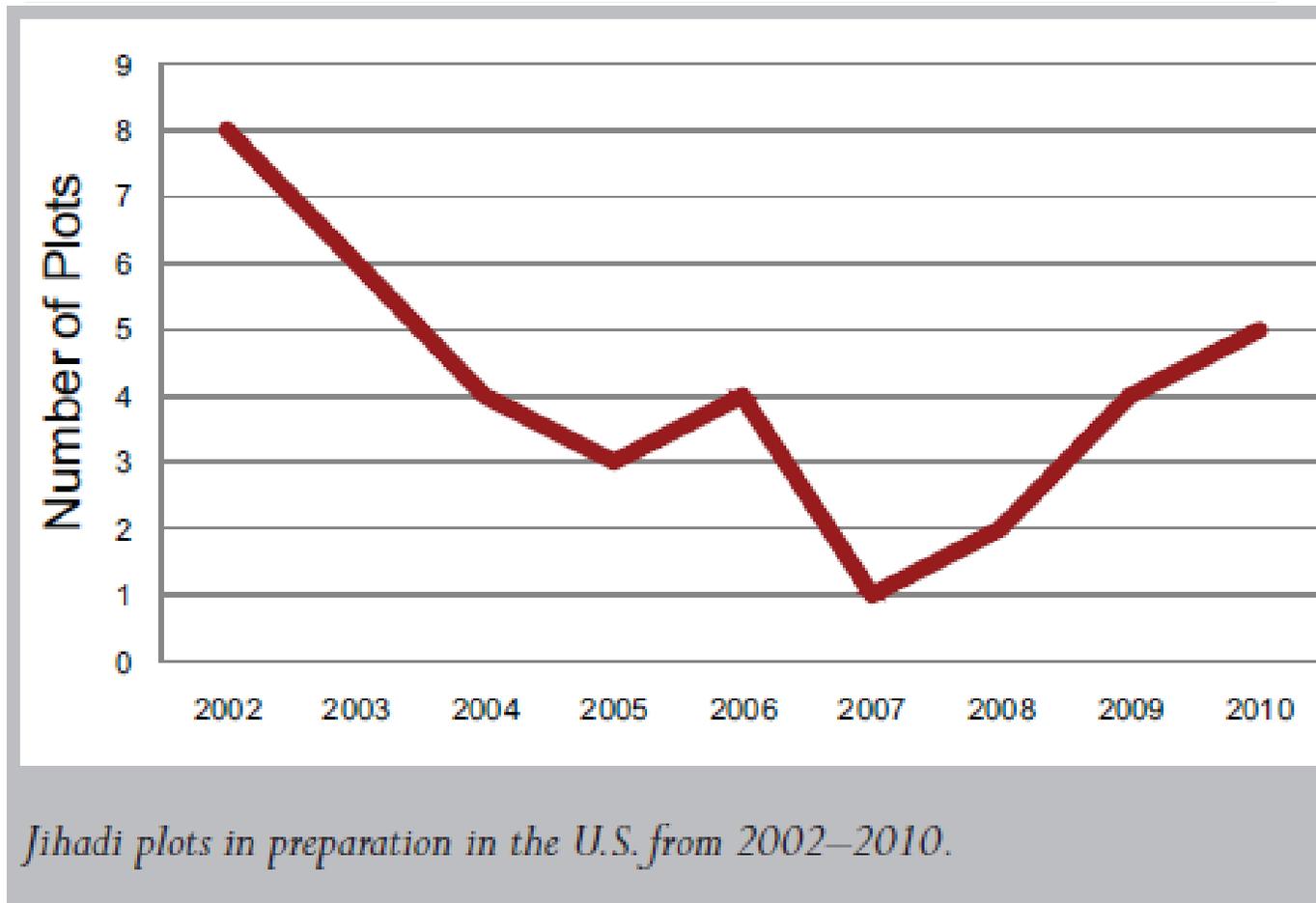
(Courtesy WBRG)

# World Trade Center September 11th, 2001

- Both 110-floor Twin Towers of the World Trade Center were destroyed along with 5 others establishments (including 2 subway stations)
- 25 surrounding buildings were damaged
- 2749 people were killed in WTC and on board both American flight 11 and United flight 175



# Who are the threats?



[http://www.rms.com/Publications/9\\_11\\_Retrospective.pdf](http://www.rms.com/Publications/9_11_Retrospective.pdf)

# Motives as Reported in ATF Database

**Table 5** Number of deaths by etiology for explosive, incendiary, and premature bombing events from January 1, 1983, to December 31, 2002

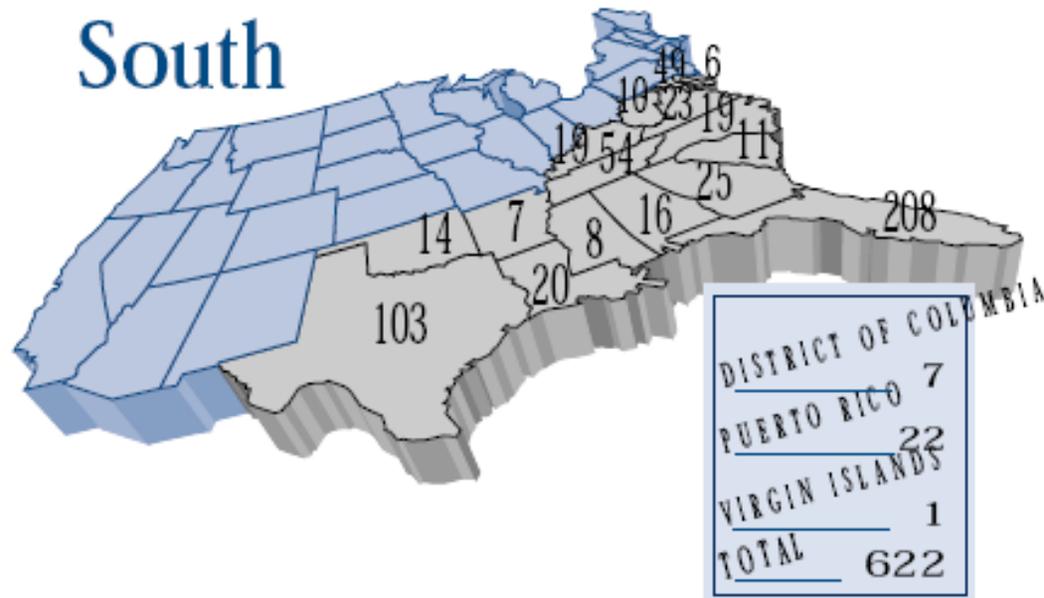
Etiology of Bombing Event Deaths	Explosive (%)	Incendiary (%)	Premature (%)
Determined	363 (94.0)	129 (92.8)	75 (43.1)
Homicide	268 (69.4)	69 (49.6)	10 (5.7)
Suicide	53 (13.7)	3 (2.2)	1 (0.6)
Vandalism	10 (2.6)	3 (2.2)	54 (31.0)
Revenge	14 (3.6)	40 (28.8)	5 (2.9)
Protest	0 (0.0)	0 (0.0)	0 (0.0)
Labor-related	0 (0.0)	0 (0.0)	0 (0.0)
Extortion	1 (0.3)	1 (0.7)	1 (0.6)
Excitement	1 (0.3)	0 (0.0)	3 (1.7)
Domestic violence	13 (3.4)	3 (2.2)	0 (0.0)
Insurance fraud	3 (0.8)	3 (2.2)	1 (0.6)
Intimidation	0 (0.0)	7 (5.0)	0 (0.0)
Undetermined	23 (6.0)	10 (7.2)	99 (56.9)
Total	386 (100.0)	139 (100.0)	174 (100.0)

**Table 7** Number of injuries and deaths by explosive material from January 1, 1983, to December 31, 2002

Type of Material	Injuries (%)	Deaths (%)
Determined	4,050 (68.3)	595 (85.1)
Nitrate-based fertilizers	1,586 (26.7)	181 (25.9)
Smokeless powder	818 (13.8)	114 (16.3)
Inflammable liquids	579 (9.8)	139 (19.9)
Black powder	526 (8.9)	47 (6.7)
Pyrotechnics	232 (3.9)	18 (2.6)
Dynamite	161 (2.7)	90 (12.9)
Match heads	139 (2.3)	2 (0.3)
C-4	5 (0.1)	1 (0.1)
Trinitrotoluene	4 (0.1)	3 (0.4)
Undetermined	1,881 (31.7)	104 (14.9)
Total	5,931 (100.0)	699 (100.0)

## INCIDENTS BY STATE

### South



STATE	EXPLOSIVES		INCENDIARIES		STATE	EXPLOSIVES		INCENDIARIES	
	actual	attempt	actual	attempt		actual	attempt	actual	attempt
ALABAMA	7	1	6	2	NORTH CAROLINA	11	3	4	1
ARKANSAS	4	2	0	1	OKLAHOMA	10	2	2	0
DELAWARE	2	1	2	1	SOUTH CAROLINA	10	0	1	0
DISTRICT OF COLUMBIA	1	1	5	0	TENNESSEE	25	1	18	10
FLORIDA	135	26	36	11	TEXAS	61	25	9	8
GEORGIA	17	7	1	0	VIRGINIA	9	3	9	2
KENTUCKY	12	2	5	0	WEST VIRGINIA	6	1	3	0
LOUISIANA	7	8	3	2	PUERTO RICO	9	3	8	2
MARYLAND	29	8	5	7	VIRGIN ISLANDS	1	0	0	0
MISSISSIPPI	3	1	2	2	TOTALS	359	95	119	49

# Special Characteristics of Bombing Victims

- Victims of terrorist bombings (n = 906) were compared with 55,033 casualties of non-terror related trauma.
- Bombing resulted in significantly different:
  - Injury complexity
  - Increased severity
  - More body regions involved
  - Enhanced use of intensive care
  - Prolonged hospital stay
  - More surgical interventions
  - Increased hospital mortality



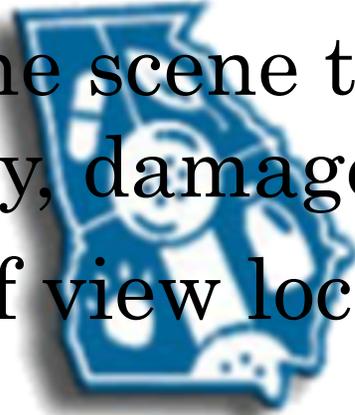
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# Prehospital

- Incident command
- Securing the area
- Secondary device survey
- Triage categorization
- Regular trauma protocols
- Radiation survey
- Survey for chemical contamination
- Did the blast occur in an enclosed setting?

# Secondary Devices

- Secondary explosive devices are designed to explode after a primary explosion has attracted large numbers of responders to the scene to inflict additional injury, damage, and fear.
- Hidden in out of view locations, or camouflaged



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# U.S. Fire Administration Guidelines

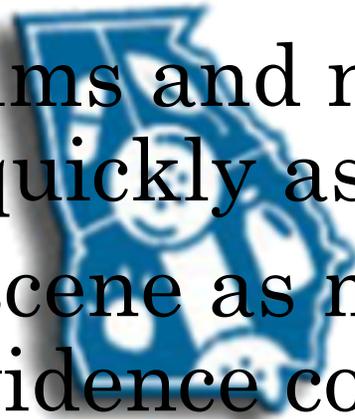
- Anticipate the presence of a secondary device at any suspicious incident.
- Search for a secondary device before moving into the incident area.
- Avoid touching or moving anything that may conceal an explosive device.



Georgia Police

# U.S. Fire Administration Guidelines

- Effectively manage the scene with boundaries, exclusion zones, triage areas, etc.
- Evacuate victims and non-essential personnel as quickly as possible.
- Preserve the scene as much as possible for evidence collection and crime investigation.



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# Prehospital Special Considerations

- Judicious use of IV fluids:
  - Overzealous fluid administration may worsen primary pulmonary injury and bleeding
- Cautious mechanical ventilation:
  - Mechanical ventilation and positive pressure may increase the risk of alveolar rupture and air embolism

# Prehospital Special Considerations

- Cautious air transport
- Air embolization:
  - Place patient in a prone left lateral position with the head down

# Mass Casualty Triage

- Dynamic process
- START (Simple Triage And Rapid Treatment)
  - RPM
    - Respirations  $> 30$
    - Pulse Cap refill  $> 2$  sec
    - Mental status
- JumpStart for Pediatrics



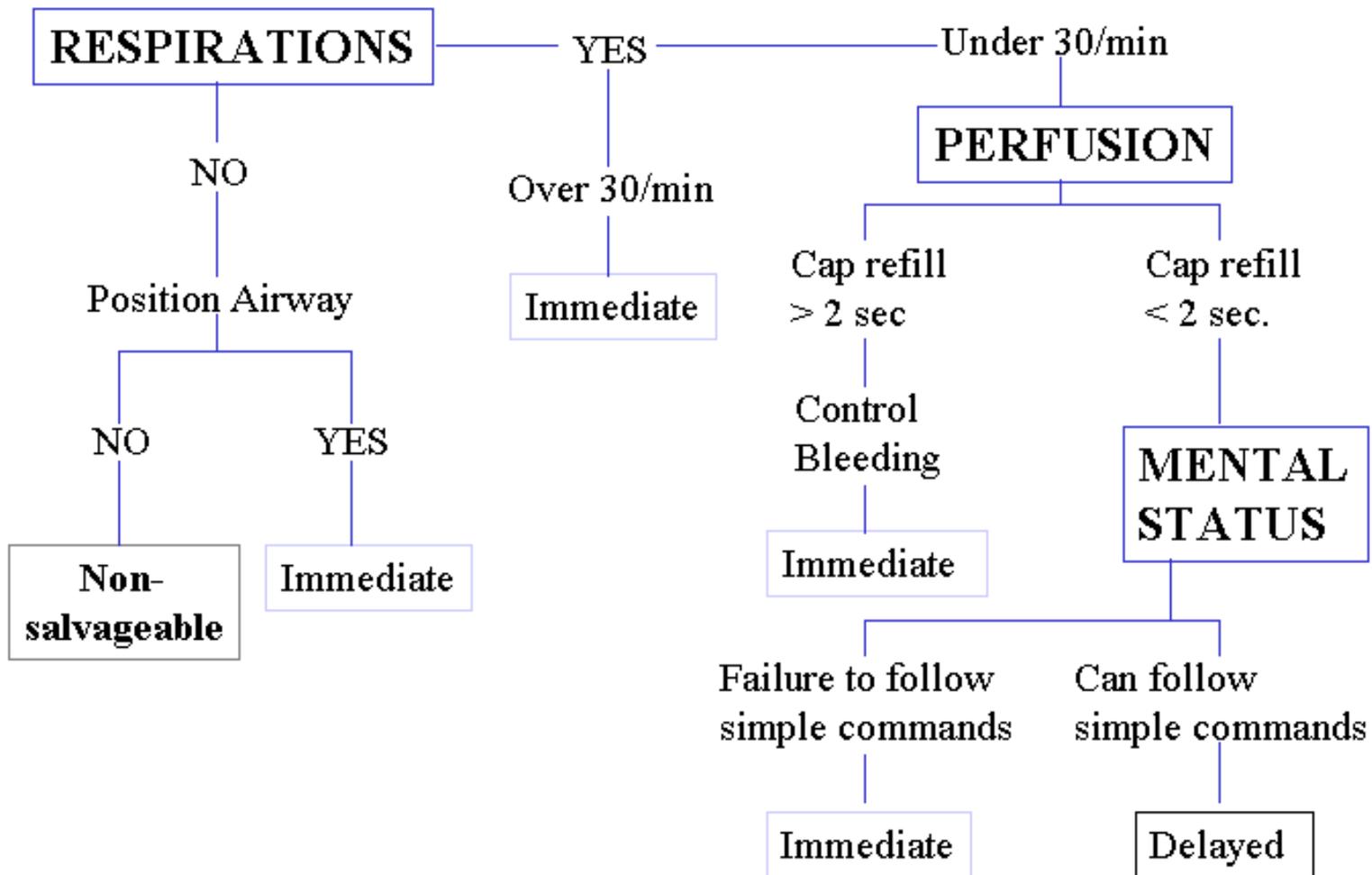
STAT

# Triage Categorization

- Red
- Yellow
- Black
- Green

- Immediate
- Delayed
- Dead or expectant
- Minimal

# START Triage



No. 239352 **TRIAGE TAG** No. 239352  
 PART I  
 No. 239352  
 CALIFORNIA FIRE CHIEFS ASSOCIATION®  
 Leave the correct Triage Category ON the end of the Triage Tag

Move the Walking Wounded **MINOR**  
 No respirations after head tilt **DECEASED**  
 Respirations - Over 30 **IMMEDIATE**  
 Perfusion - Capillary refill Over 2 seconds **IMMEDIATE**  
 Mental Status - Unable to follow simple commands **IMMEDIATE**  
 Otherwise- **DELAYED**

MAJOR INJURIES: \_\_\_\_\_  
 HOSPITAL DESTINATION: \_\_\_\_\_

ORIENTED  DISORIENTED  UNCONSCIOUS

TIME	PULSE	B/P	RESPIRATION

**DECEASED**  
**IMMEDIATE** No. 239352  
**DELAYED** No. 239352  
**MINOR** No. 239352

**TRIAGE TAG**  
 PART II

MEDICAL COMPLAINTS/HISTORY  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

ALLERGIES:  
 PATIENT Rx:  

TIME	DRUG SOLUTION			DOSE
	D <sub>2</sub> W	R/L	NS	

 NOTES:  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

PERSONAL INFORMATION  
 NAME: \_\_\_\_\_  
 ADDRESS: \_\_\_\_\_  
 CITY: \_\_\_\_\_ TEL. NO.: \_\_\_\_\_  
 MALE  FEMALE  AGE: \_\_\_\_\_ WEIGHT: \_\_\_\_\_

**DECEASED**  
**IMMEDIATE**  
**DELAYED**  
**MINOR**

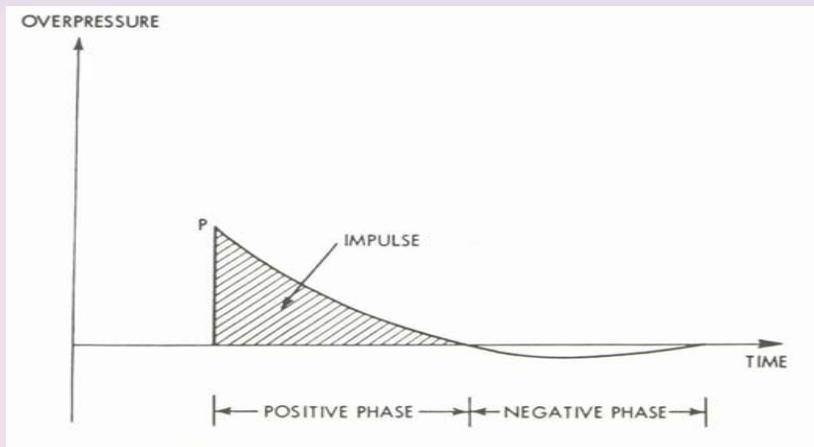
# Transport

- Transport to the nearest facility of red patients
- Green patients should be directed to other hospitals that are further away and that are not necessarily level I trauma centers

# Primary Blast Injury

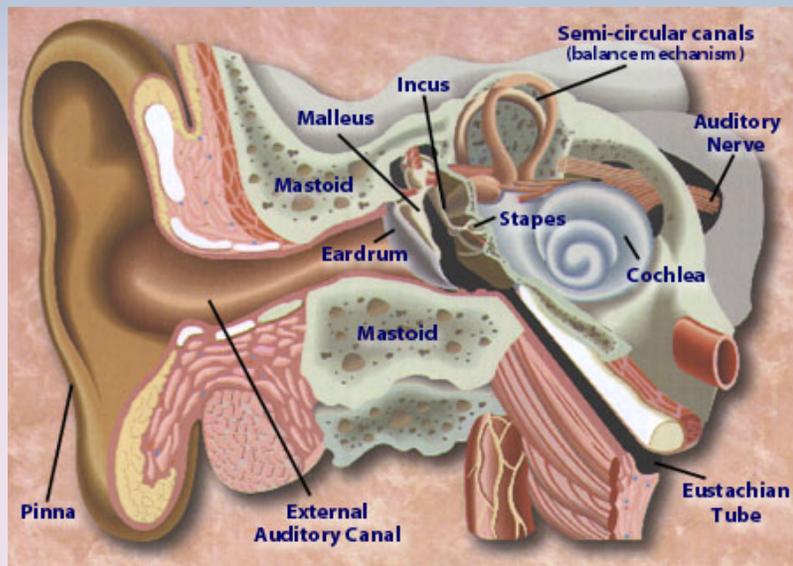


- Injuries that results from the pressure wave itself





# Blast Ear



## Signs and Symptoms

Ears ringing  
Hearing loss  
Bloody ears

# TM Perforation

- Keep dry
- Prophylactic topical antibiotic
  - Gentamycin suspension
- Outcome is good
  - Mixed frequency hearing loss with good subjective recovery
  - High frequency sensorineural hearing loss may be more persistent
  - Severity inversely proportional to distance from bombing

# TM – Perforation

- Follow up is needed:
  - Assess for middle-ear damage
  - Audiometry
  - Cholesteatoma
  - Perilymphatic leak in patients with vertigo



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# Case Study: Afghanistan

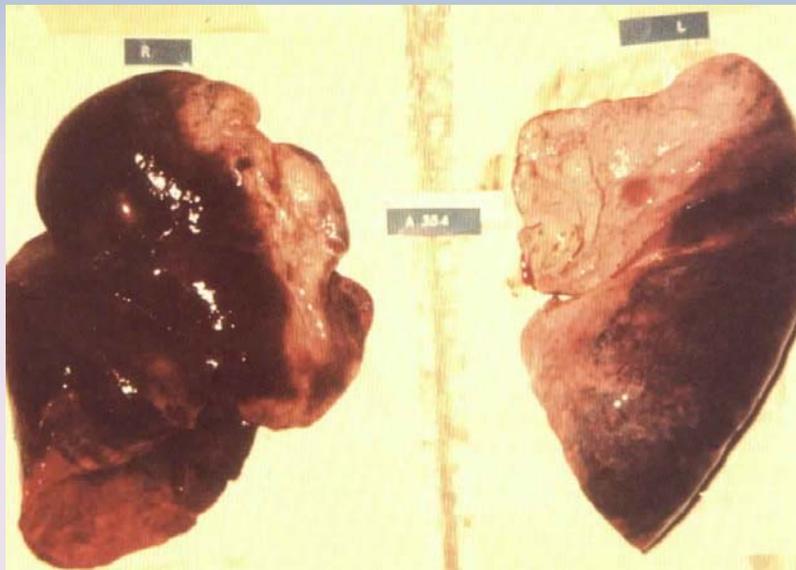


- Friendly fire incident
- 40 casualties
- 9 Americans with TM perforation
- 1 Afghani with TM perforation

# Blast Lung Injury

- Should not rely on TM rupture to predict lung injury:
  - TM perforations are found in only 60% of patients with clinically significant injuries
  - Clinically significant injuries are present in less than 30% of patients with TM perforations

# Blast Lung

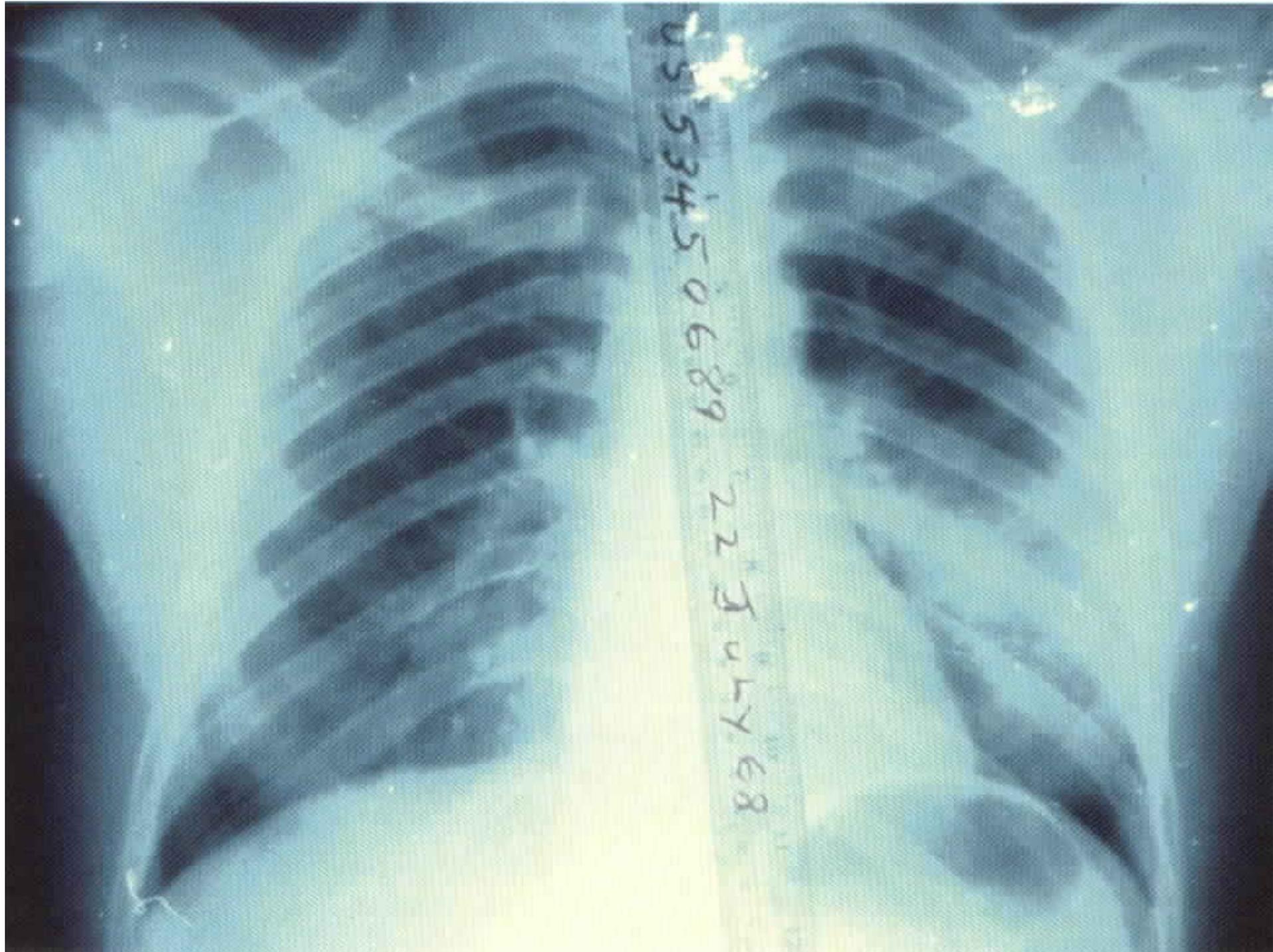


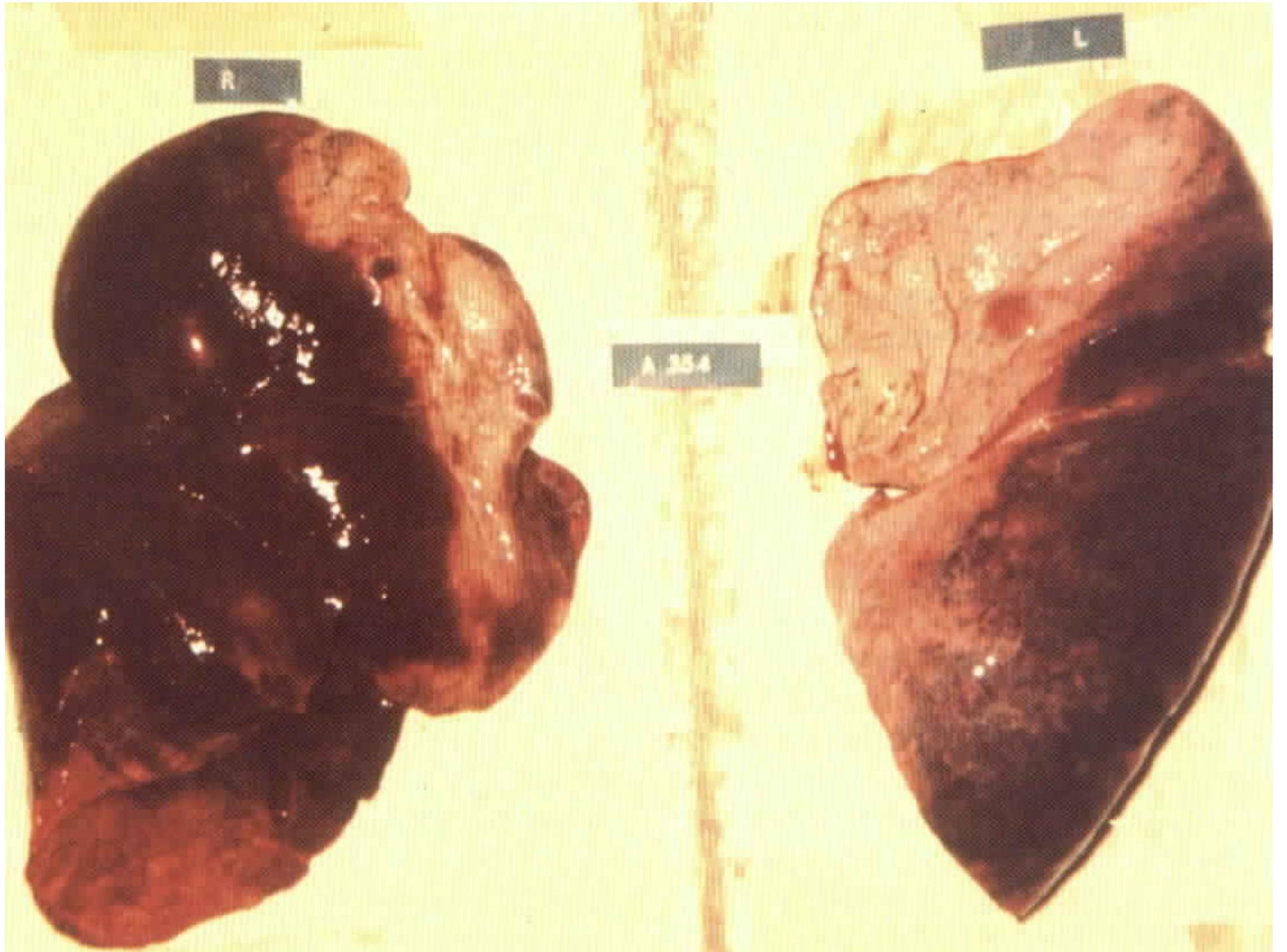
## Signs and Symptoms

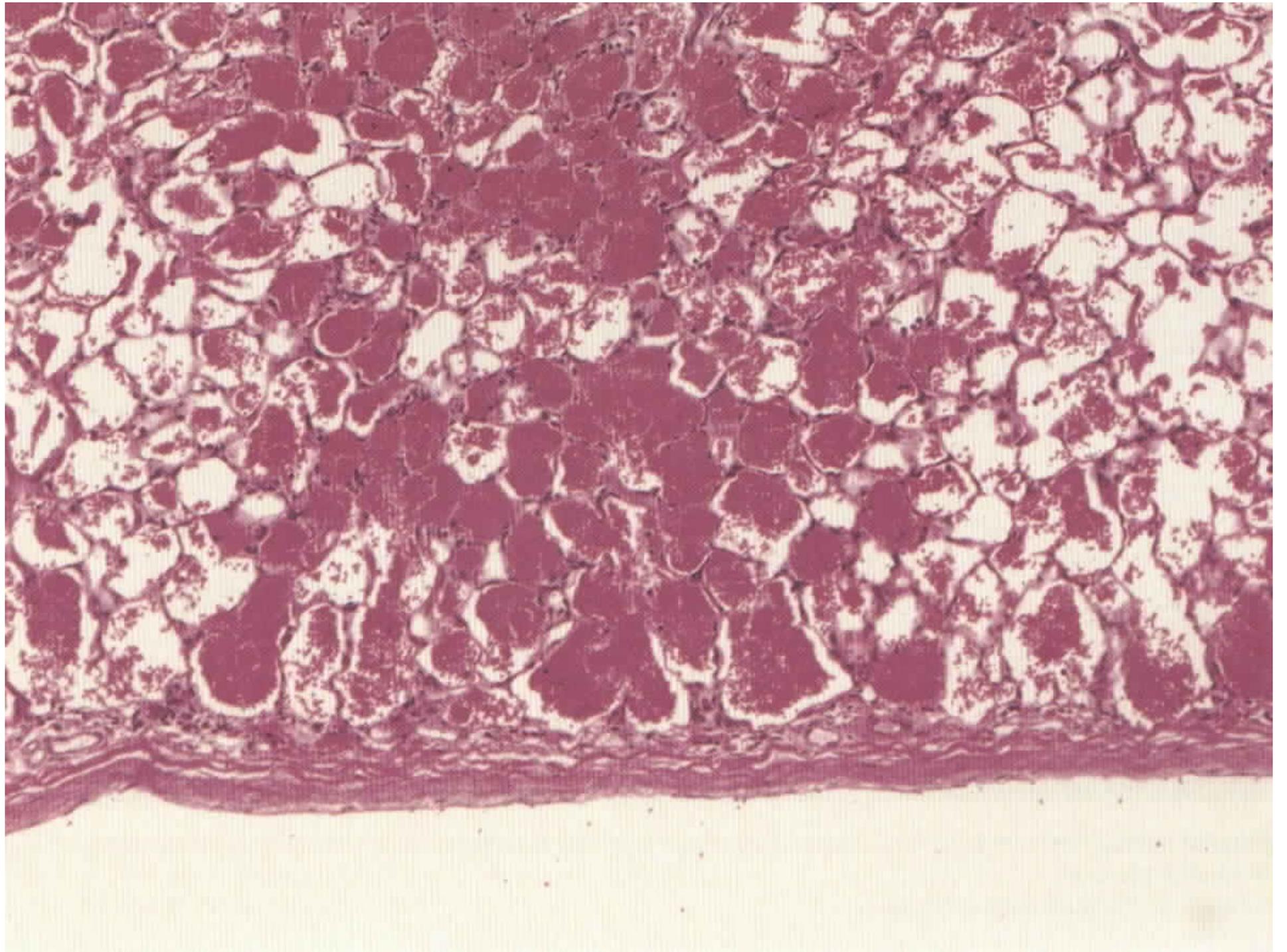
Chest pain  
Bloody/frothy spit  
Difficulty breathing

# Blast lung Injury

- Patients with normal CXR and ABGs, who have no complaints that would suggest BLI, may be discharged after a brief observation period







# Blast lung Injury

- Management similar to pulmonary contusions
- Complex fluid management
- Mechanical ventilation will increase the risk of air embolization

# Blast Belly



## Signs and Symptoms

Early:

Belly pain

Late:

Fever

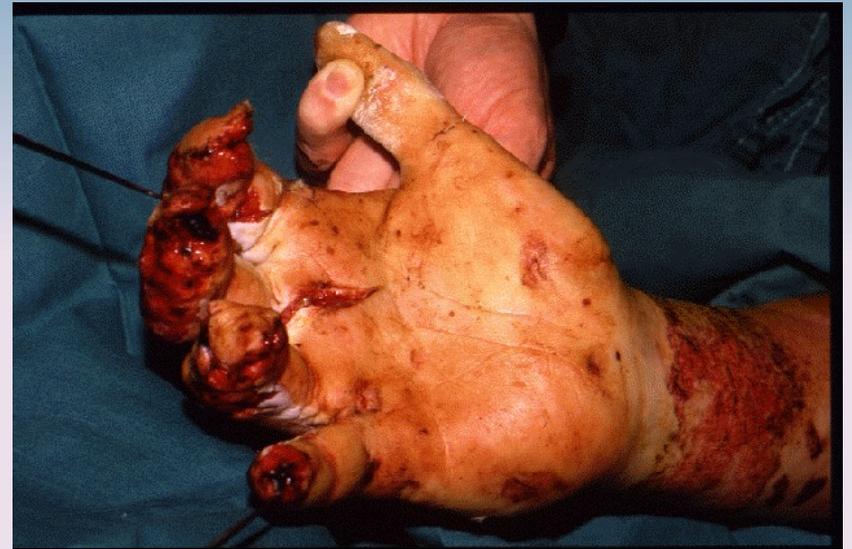
Nausea

Fast heart rate

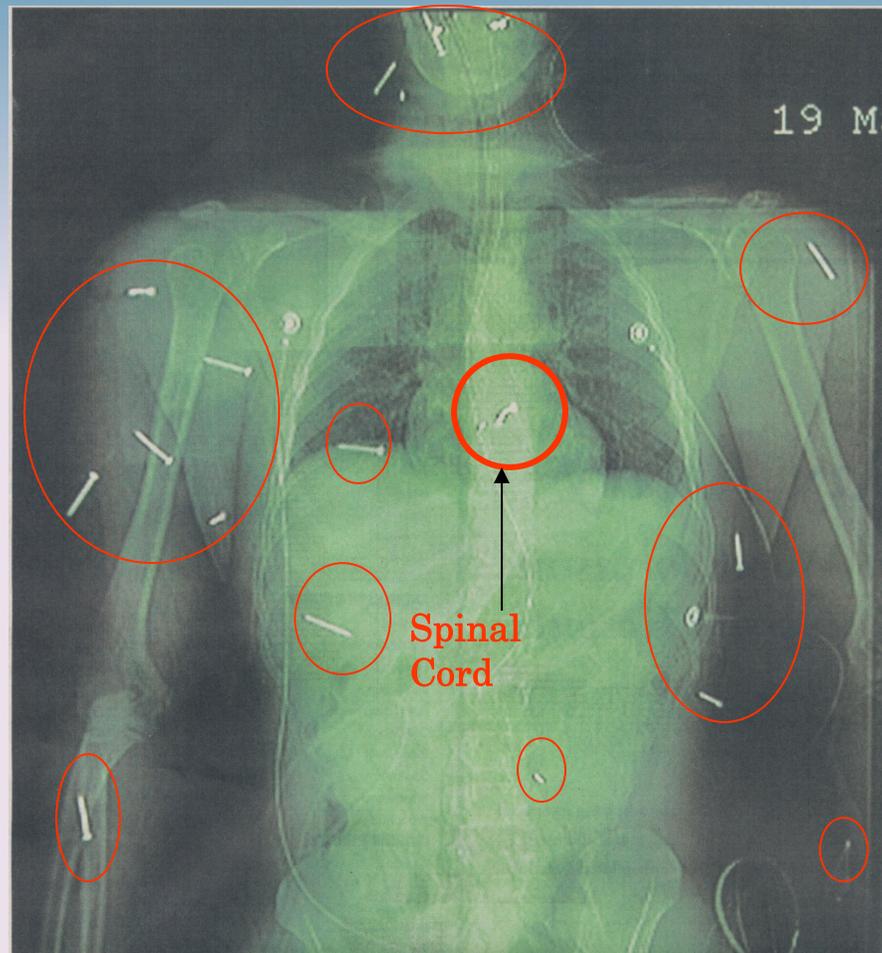
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# Management of Secondary Injuries

- As per protocol
- Watch for unusual shrapnel such as nails and bolts



# Bombing Victim



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# Management of Tertiary Injuries



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# Management of Tertiary injuries

- As per trauma protocols
- Look for crush syndrome especially in structural collapse:
  - Myoglobinuria
  - Renal failure
  - Hyperkalemia

# Management of Crush Syndrome

- IVF:
  - Start in the field
- Urinary alkalization:
  - Myoglobinuria, Urine pH>7
- Mannitol
- Hemodialysis:
  - Anuric patients, acidemic patients
  - Correction of electrolyte abnormalities
  - Advanced planning is needed for surge capacity

# Management of Quaternary injuries

- Inhalational injuries
- Carbon monoxide
- Hydrogen cyanide
- Chemical bombs or explosions
- Contamination with radionuclides and exposure to gamma radiation

# Carbon Monoxide

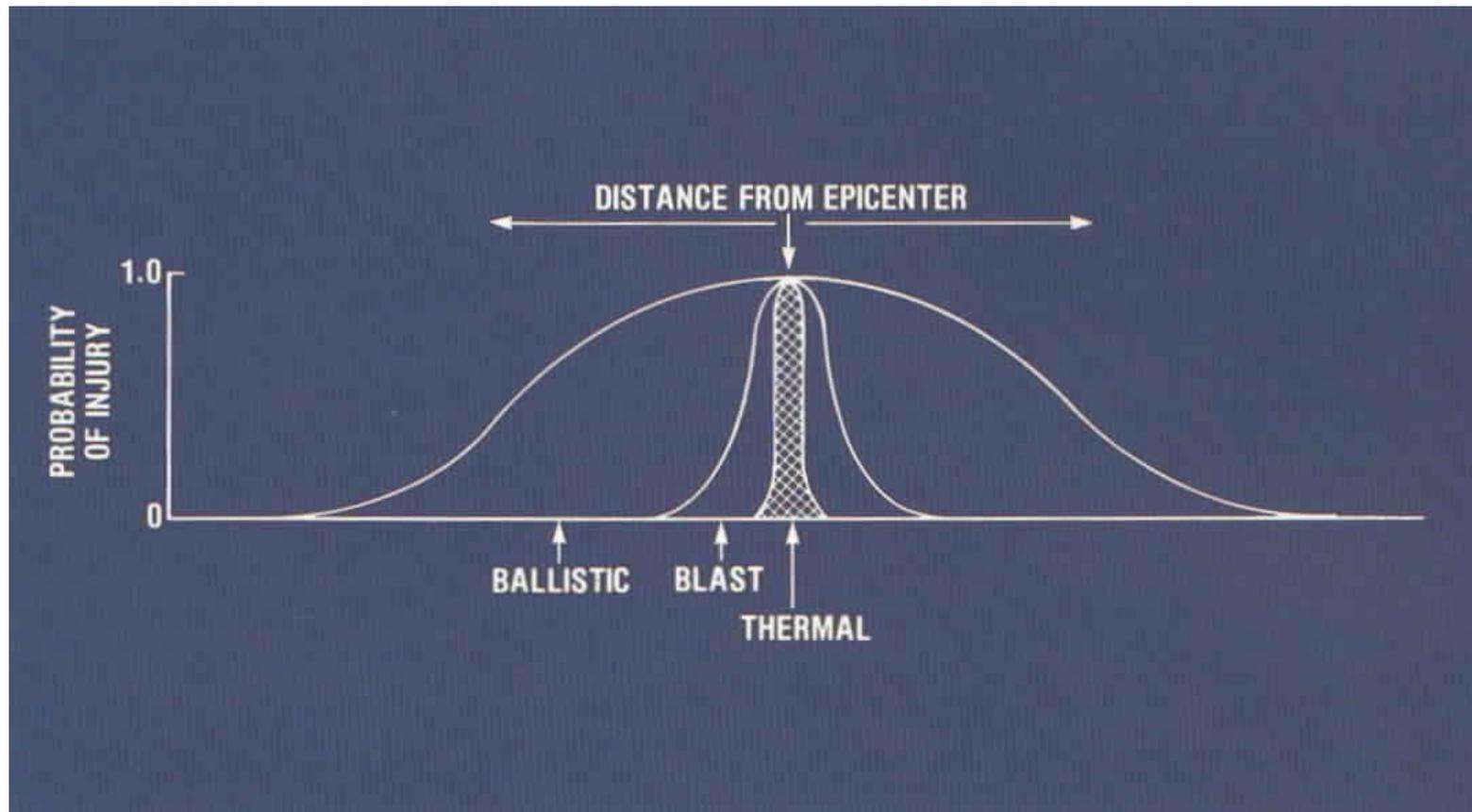
- 100% Oxygen therapy
- Hyperbaric oxygen therapy

# Cyanide Antidote Kit

- AKA the Lilly kit
- Contains:
  - Amyl nitrite pearls
  - Sodium nitrite
  - Sodium thiosulfate



# How close is too close?



# Questions?



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