# Bioterrorism for Pharmacists


## Jeffrey Michael Franc

MD, CCFP.EM, Dip Sport Med, EMDM

Associate Clinical Professor of Emergency Medicine
University of Alberta

Visiting Professor in Disaster Medicine
Università degli Studi del Piemonte Orientale
Novara, Italy

Medical Director Emergency / Disaster Management
Alberta Health Services



UNIVERSITY OF ALBERTA

# Objectives

- Review basic concepts bioterrorism
- Know necessary specifics
  - Etiology
  - Diagnosis
  - Treatment

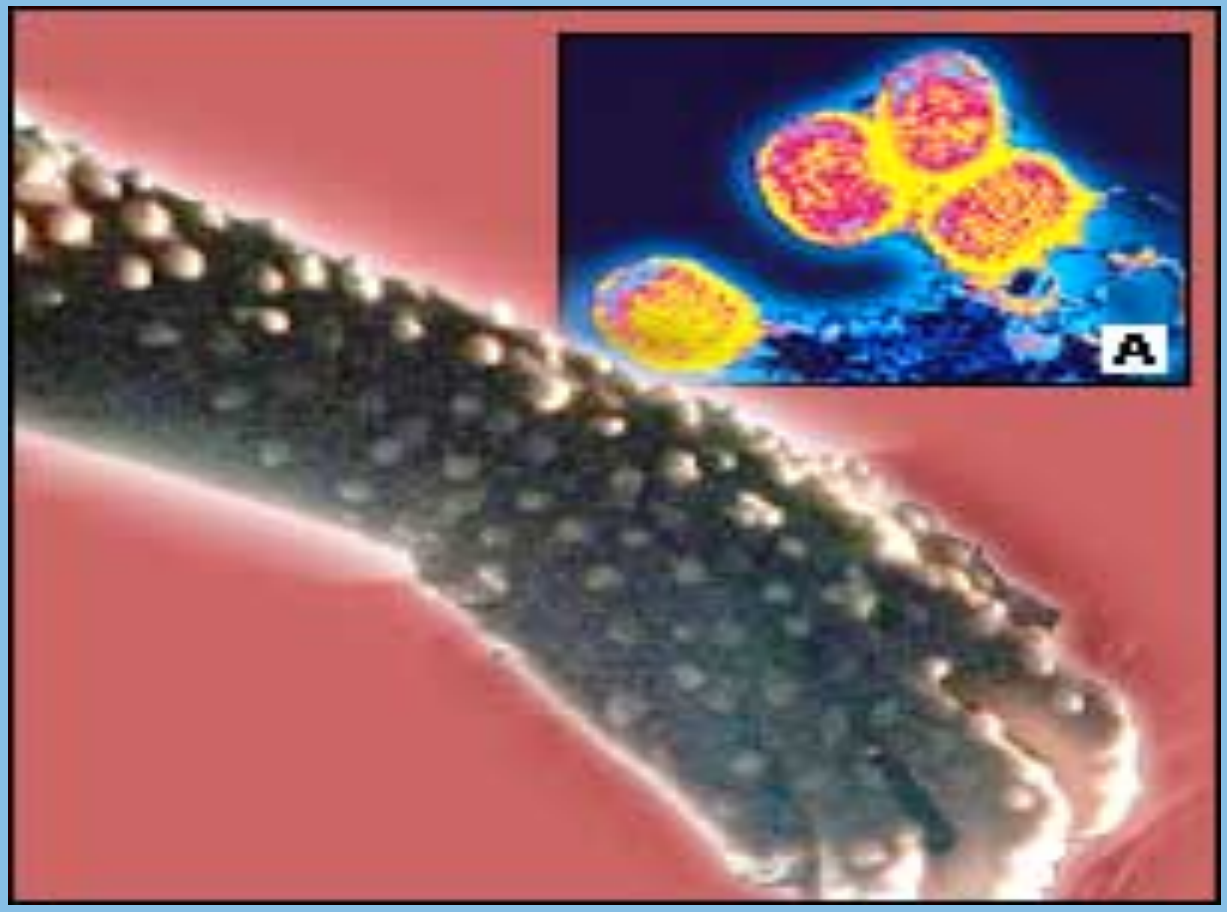
# Bad News

- Many new and unusual agents
- Seemingly large volume of knowledge
- All seem foreign

# Good News

- Good basic supportive care is the most important
- Many agents do not have specific antidotes or interventions.
- Nobody is an expert on this...we are all in the same situation.
  - Most of us have never seen these illnesses

# Biological Agents



# Biological Agents: Background

- Long clinical latency
- Health care workers likely to be first responders
- Initial symptoms all non specific
- Most are disease rarely seen in practice
  - All health care providers will be inexperienced
- Epidemiological clues are the key
- Accurate field tests not available

# Biological Agents

What are characteristics of an ideal bioweapon?

# Biological Agents

- Ideal bioweapon is..
  - Easily obtainable and culturable.
  - Stable in the environment
  - Easily weaponized
  - No innate resistance or simple treatments.

# Biological Agents:  Cat A

Which are the CDC Category A Agents?


HINT: (High risk, easily disseminated, high mortality rate)

# Biological Agents:  Category A

- Anthrax
- Smallpox
- Plague
- Botulism toxin
- Tularemia
- Hemorrhagic fever viruses
  - Arenaviruses (lasso fever, etc)
  - Filoviruses (ebola, marburg)

# Biological Agents:  Cat B

Which are the CDC Category B Agents?


HINT: (Easily disseminated, low mortality, high morbidity)

# Biological Agents: Cat B

- Q-fever
- Brucellosis
- Glanders
- Viral encephalitis
- Ricin
- Staphylococcal toxins
- Various gastroenteritides

# Biological Agents:  Cat C

Which are the CDC Category C Agents?


HINT: (Emerging Threats which need to be bioengineered for weapon use)

# Biological Agents: Cat C

- Hantavirus
- Yellow fever
- multi-drug resistant TB

# Biological Agents: Misc

- HIV
- Adenovirus
- Influenza
- Rotavirus
- Hybrids (Ebola-plague, Smallpox-plague)

# Biological Agents

- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Biological Agents: Anthrax

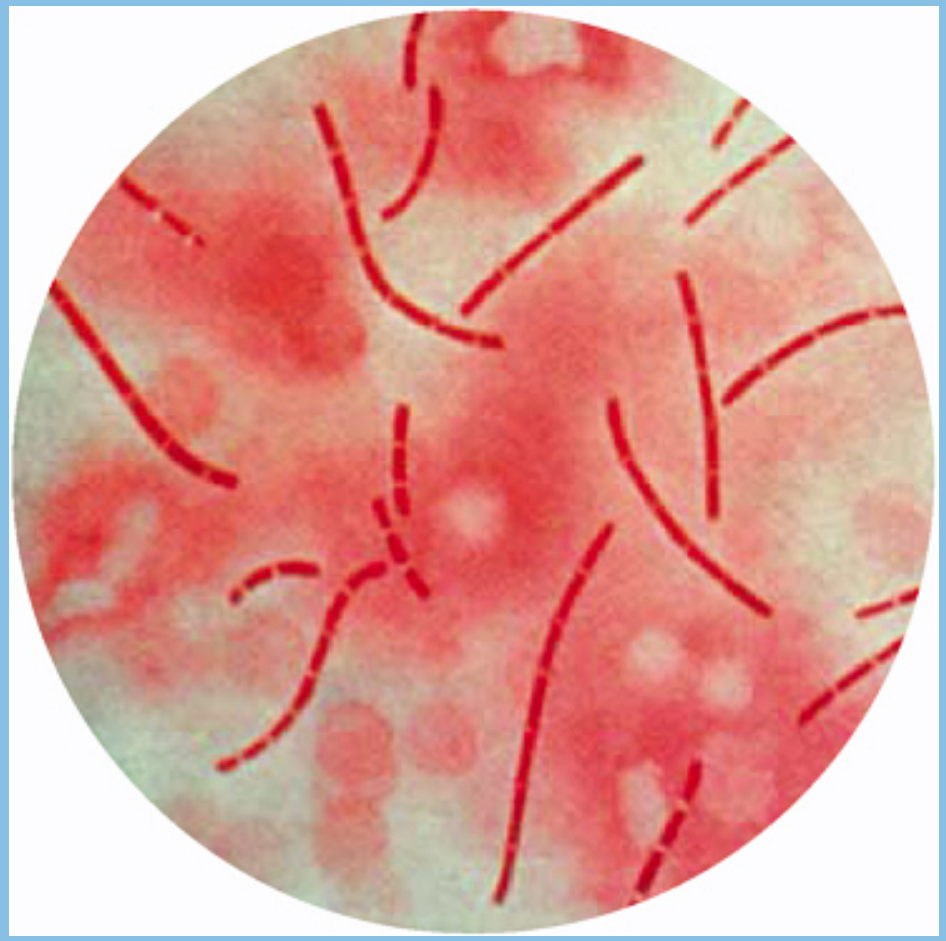
- Gram + Spore forming bacteria
- Found in soil throughout the world
- 1-3 Inhaled spore forming bacteria
- No person to person spread
- In humans found in three forms:
  - Cutaneous
  - Gastrointestinal
  - ***Pulmonary***

# Anthrax: Cutaneous

- Most common form
- Direct contact with hides of herbivores
  - Sheep
  - Goats
  - Cows
- Approximately 200 cases per year reported
- Spore germinates in skin and toxins produce edema
- Eschar forms

# Anthrax: Gastrointestinal

- Least Common Form
- Ingestion of insufficiently cooked contaminated meat
- Presents with:
  - Nausea
  - Vomiting
  - Diarrhea
  - Ascites
  - Sepsis



# Anthrax: Pulmonary

- Wool Sorter's Disease
- Reach lungs from contaminated hides

# Pulmonary Anthrax: Mechanism

- Spores are inhaled
  - Deposited on alveolar surface
  - Phagocytosed by macrophages
  - Surviving spores transported to nodes and germinate
  - Mediastinal edema and necrosis
  - Bacteremia / Sepsis
- Incubation 1-5 days (up to 60d)
- Not pneumonia:  Hemorrhagic Mediastinitis and sepsis

# Anthrax: Symptoms

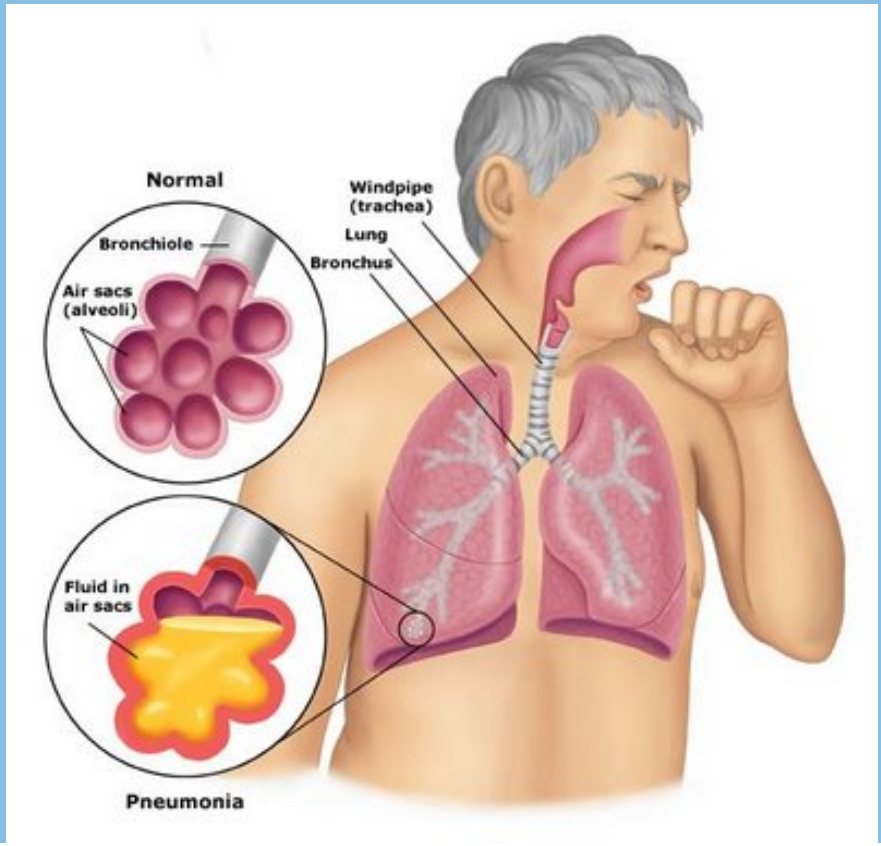
- Initially very non-specific:
  - Fever (almost 100%)
  - Dyspnea (80%)
  - Cough
  - Headache / Chills  / Vomiting
- Wide mediastinum (70%)
- Pleural effusion (80%)
- No rhinorrhea (90%)
- Absence of sore throat (80%)

# Anthrax Symptoms

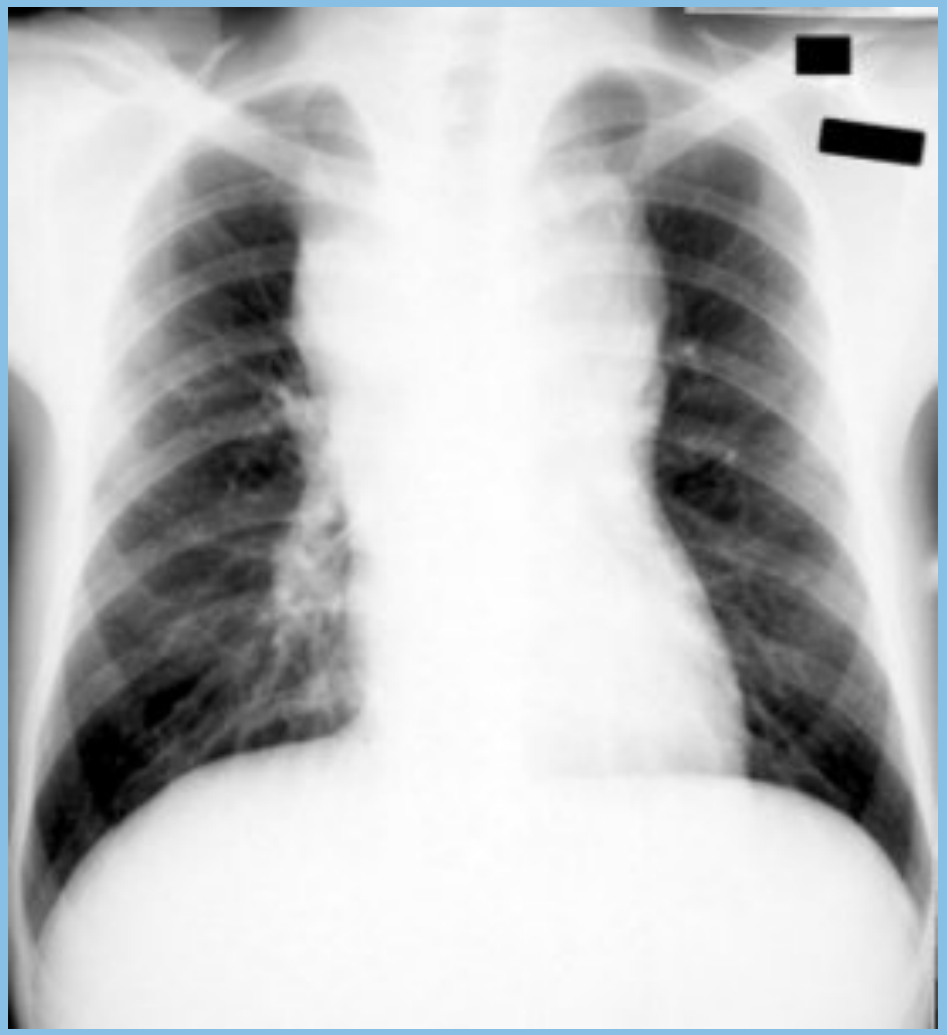
Anthrax symptoms mimic which disease(s)?

# Anthrax vs Pneumonia / Influenza

- Anthrax
  - Nausea
  - Vomiting
  - Diaphoresis
  - Altered mental state
  - HR > 110
  - Fever
- Pneumonia / Influenza
  - Fewer GI symptoms



# Anthrax: Diagnosis



- Routine laboratory usually not helpful
- Blood cultures
- Chest xray very helpful:
  - Mediastinal Widening
  - Pleural effusions

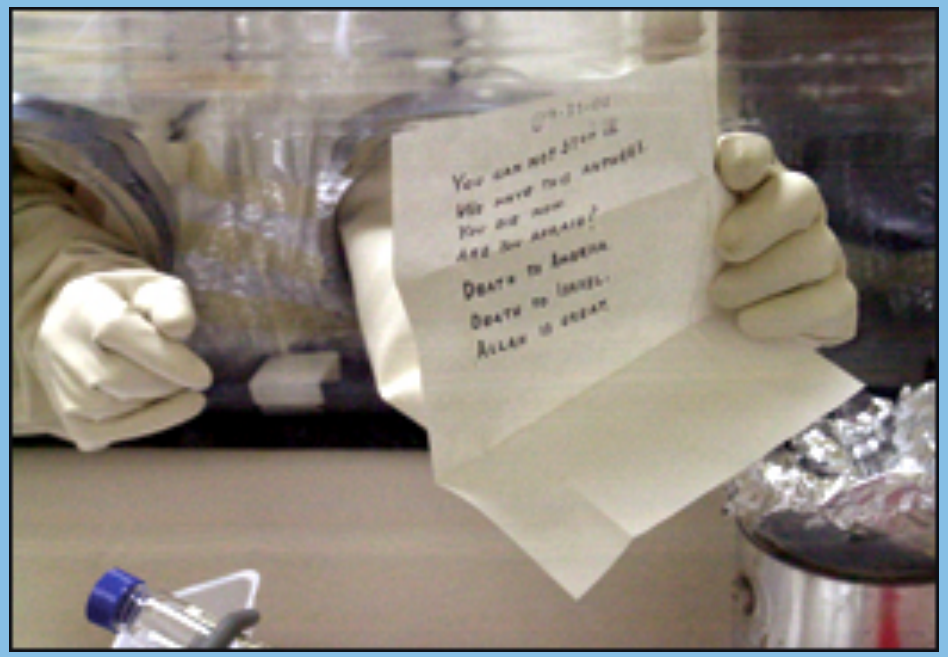
# Anthrax: Treatment

- Early Diagnosis is ESSENTIAL
  - If diagnosis delayed from 2 to 5 days = Doubled Mortality
- Some resistance to beta lactams
  - (not concentrated in phagocytes)
- Cipro or doxy +
  - Rifampin / Vancomycin / Impepenem / Clindamycin
- Treatment at least 60 days
- For patients with meningitis:
  - Cipro with chloramphenicol / rifampin / or penicillen
  - (Doxycycline has poor CSF penetration)

# Anthrax

2001 Anthrax was distributed in letters through the US postal system.  5 people die.  17 are seriously ill.

Which antibiotic does CDC recommend for prophylaxis?
Why?
How about in children?



# Anthrax: Prophylaxis

# Anthrax: Post Exposure

1) Antibiotics x 60 day (cipro/doxy) with monitoring for illness
2) Antibiotics x 100 days
3) Antibiotics x 100 days + 3 doses ANA

# Anthrax: Vaccine

- Anthrax Vaccine Absorbed (AVA)
  - High risk individuals only
  - Six inoculations over 18m
- Several other vaccines in development
  - Including a single-dose oral preparation

# Anthrax

What type of infection control measures are necessary?


# Anthrax:  Personal Protection

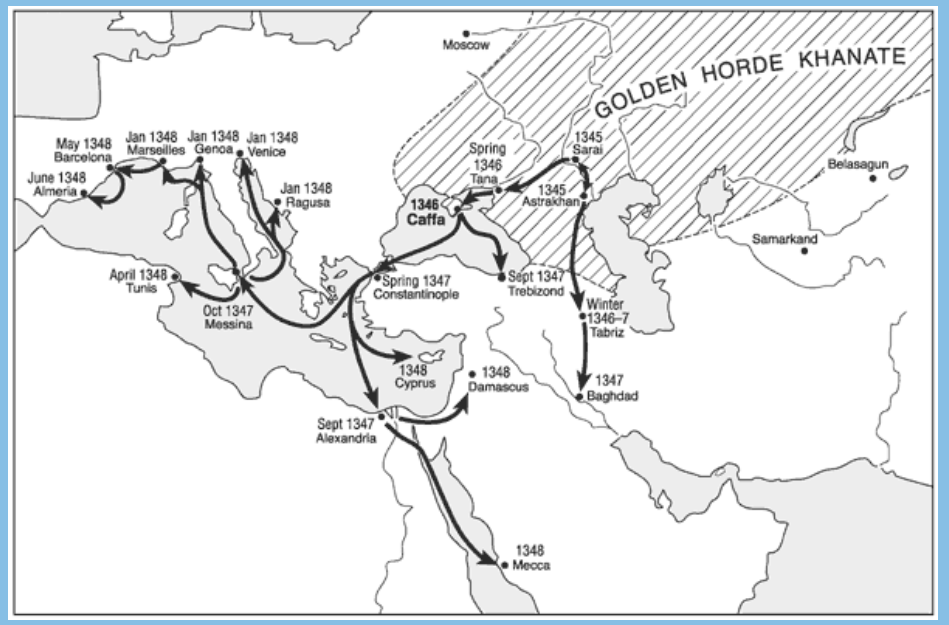
- Standard precautions
- Respiratory isolation NOT required

# Biological Agents

- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Caffa: 1346

- Tartars of Asia minor chase the Genovese to their fortified town in Caffa
- Catapult dead bodies infected with plague over the walls
- Infected Genovese return to Italy
- Plague spreads rapidly across Europe

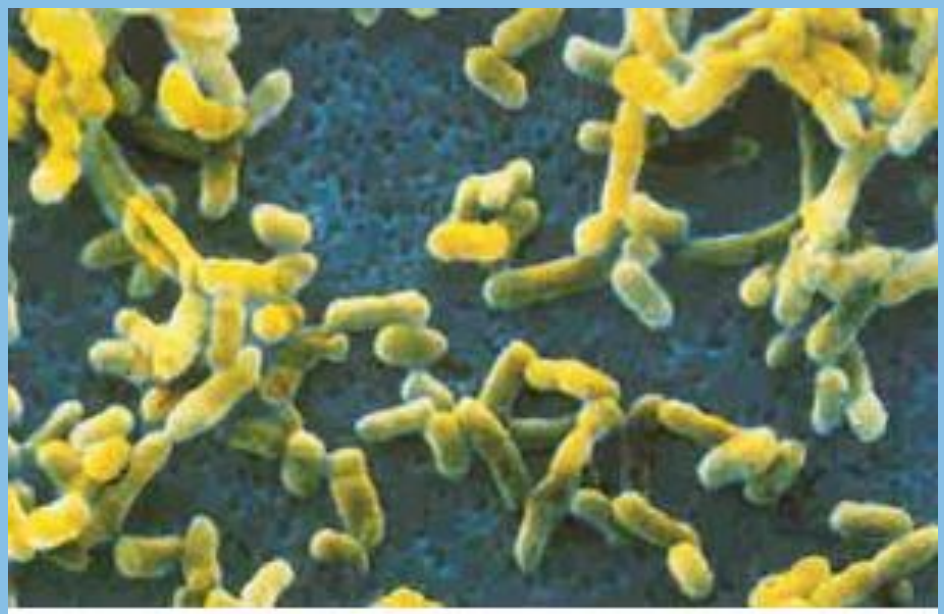


# Biological Agents: Plague

- Gram negative bacilli (bipolar staining) (Yersina pestis)
- Flea borne zoonosis
- 200 million deaths worldwide
- 1346: “Black Death”
  - 20-30 million victims
  - 1/3 of European population

# Plague: Weaponization

- WW II Japanese army drops plague infected fleas over China
- Cold war:  USA and USSR develop plague as biological weapon
- 1970 US program terminated



Yersinia pestis (Bubonic Plague)

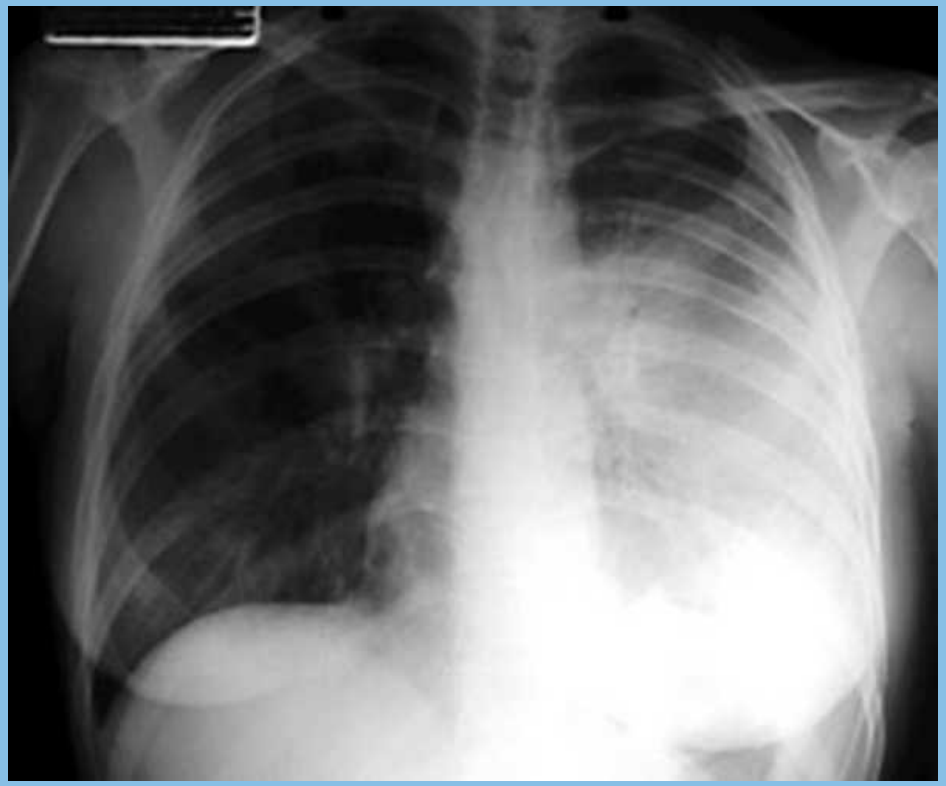
# Plague: Mechanism

- Naturally occurring on five continents
- Natural Reservoir: Rodents
- Humans naturally infected usually by fleas
- Two Forms:
  - Bubonic
  - Pneumonic

# Bubonic Plague

- 98% of naturally occuring cases
- Flea bite infects skin
- Bacteria spread to regional nodes
- Marked lymphadenopathy
- Gangrenous lesion on digits and nose
- May lead to sepsis

# Pneumonic Plague



- Less than 2% of naturally occuring cases
- For terrorist action would be primary pneumonic plague
  - Rapidly progressive pneumonia
  - Symptoms progress rapidly over 2 days
  - Cough, fever, headache, myalgia, dyspnea
  - Often fatal within 24 hours
- **Person-to-person spread**

# Pneumonic Plague

Describe the treatment of pneumonic plague.

# Plague: Treatment

- Must treat within 24h of symptoms or likely to be fatal.
- Streptomycin currently drug of choice
  - Intramuscular x 10days (or 3 days after fever abates)
- Gentamicin
- Doxycycline or Cipro PO for mass casualties
- No vaccine currently available
  - Previous vaccine not effective for pneumonic plague
  - Discontinued 1999
- Prophylaxis:  Doxy or Cipro (7 days)
- Unstable in environment.  Rapidly destroyed by sunlight
- Meticulous supportive care

# Plague

What infection control measures should be taken?

# Plague: Infection Control

- Isolate infected individuals (droplet precautions)
- Antibiotic prophylaxis if epidemic occurs
  - New cough
  - Fever >38.5c
  - Asymptomatic with infectious contacts

# Biological Agents

- Agent?
- Mechanism?
- Symptoms?
- Treatment?

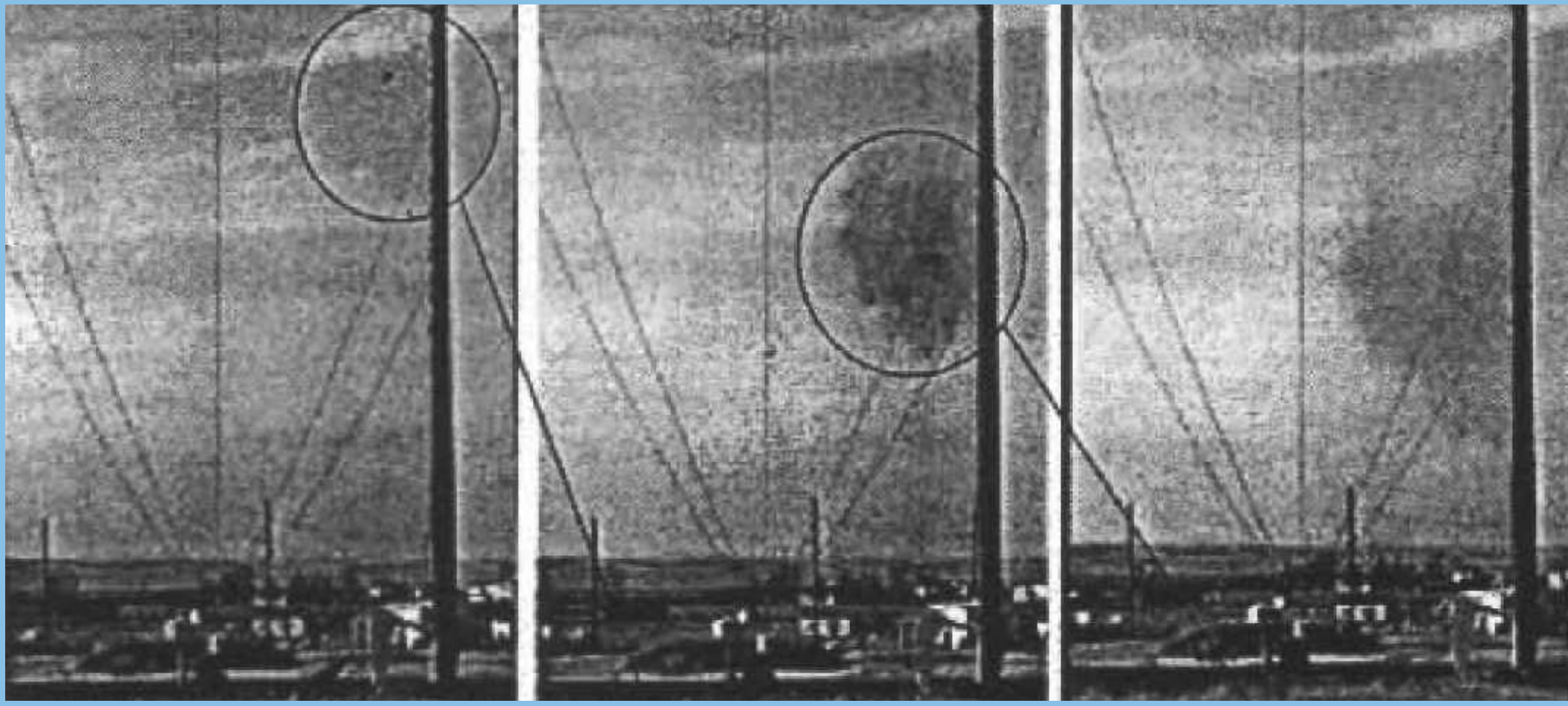
# Tularemia

- Bacterial zoonosis caused by *Francisella tularensis*
- Gram negative coccobacilli
- Affects 150 animal species worldwide
- Extremely hardy:  can survive for weeks in soil / water /meat
- Usually humans are infected by arthropod bites
- No person-to-person spread

# Tularemia

How would tularemia be weaponized?

# Tularemia: Aerosolization



# Tularemia: Aerosolization

- Commercial Crop Sprayer
  - $1095.00

- 1980 Cessna 182
  - $99,500.00

# Tularemia: Aerosolization

- Extremely infective when aerosolized: 1-50 organisms
- Weaponized by freeze drying bacteria laden slurry then grinding into a fine powder
- Part of US stockpile until 1970
- WHO report 1969 warned of this scenario:
  - 50kg of powdered Tularemia
  - Dispersed in an area of 5 million people
  - Could lead to 19 000 deaths
  - 250 000 severely ill

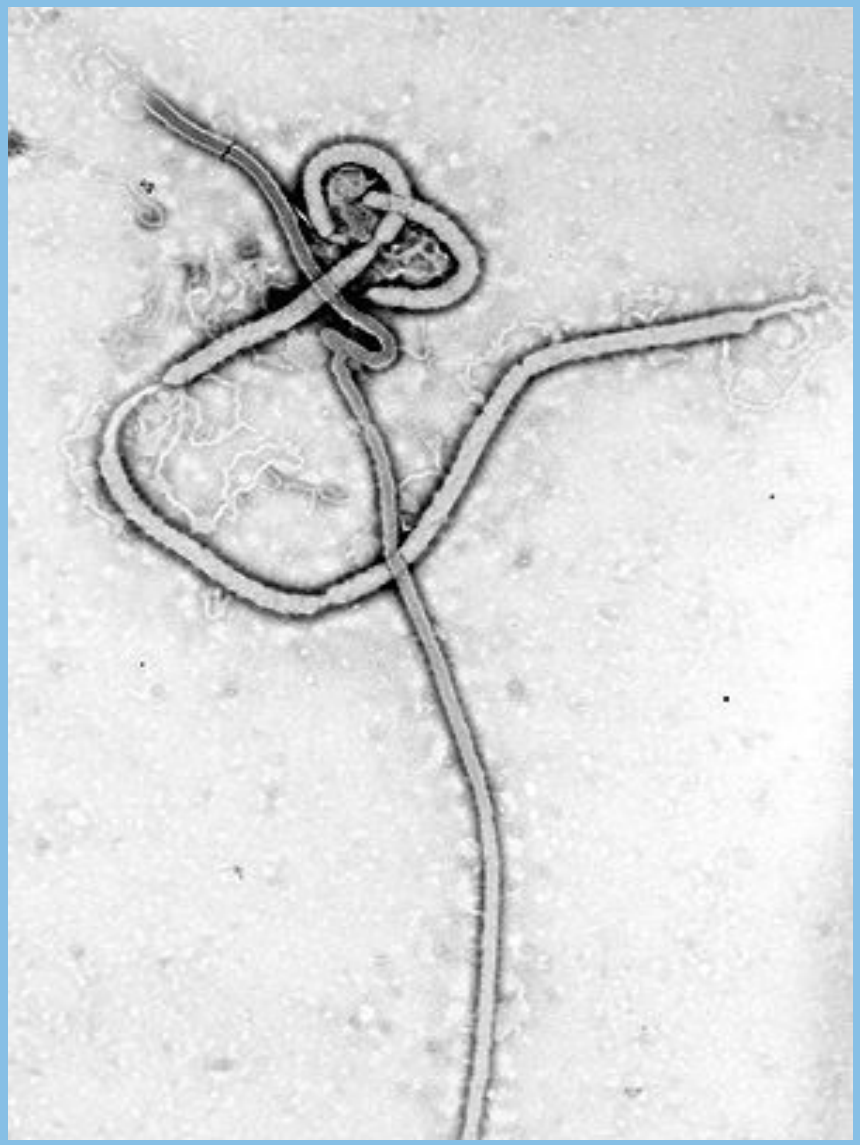
# Tularemia: Symptoms

- Infection occurs 3-5 days after infection
- Abrupt onset of fever, chills, malaise, coryza, sore throat
- Pneumonia with hilar adenopathy
- Complications: meningitis, pericarditis, hepatitis, sepsis
- Slower progression and less mortality than anthrax
- No person-to-person transmission

# Tularemia: Treatment

- Streptomycin 1 gram IN BID x 10 days
- Cipro / Doxycycline in mass casualty events
- Prophylaxis:  Cipro or doxy
  - Only those exposed to the initial even
- Vaccine since 1930 but not avail (not licensed)
- Decontaminate exposed surface

# Biological Agents



- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Biological Agents:  Arena/Filoviruses

- Single stranded RNA viruses, usual host is rodents and arthropods
- Filoviruses: Ebola, Marburg
- Arenaviruses: Lassa, New World Arenavirus
- Bunyaviruses: Crimean-Congo Haemorrhagic Fever, Rift Valley Fever
- Flaviviruses: Yellow Fever, Omsk Haemorrhagic fever

# Arena / Filovirus: Mechanism

- Human infection caused by....
  - Bite of infected arthropod
  - Aerosol
  - *** Direct contact with secretions / blood ***
- Infects endothelial cells and induces capillary leak
- 30 – 50% mortality
- Person-to-person transmission
- Incubation 3-19 days

# Arena / Filovirus: Symptoms

- Prodrome (<1 week):
  - Fever, headache, malaise, myalgia
  - Abdominal pain, vomiting, diarrhea
- Hemorrhagic manifestations (70%)
  - Melena, epistaxis, hematemesis, hemoptysis
- Derm manifestations
  - Maculopapular rash, pettechiae, desquamation
  - Conjunctivitis
- Systemic symptoms
  - Disseminated intravascular coagulation
  - Hypotension, shock
  - Delerium, seizures, coma

# Arena / Filovirus: Treatment

- Aggressive treatment of complications
- Ribovirin (+/- Arenaviruses, not filovirus)
- ?passive immunity (convalescent plasma)
- Vaccines (Yellow Fever only)
  - Takes longer than the 3-6 day incubation period to develop immunity

# Arena / Filoviruses

What infection control measures should be taken?

# Biological Agents

- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Biological Agents: Smallpox

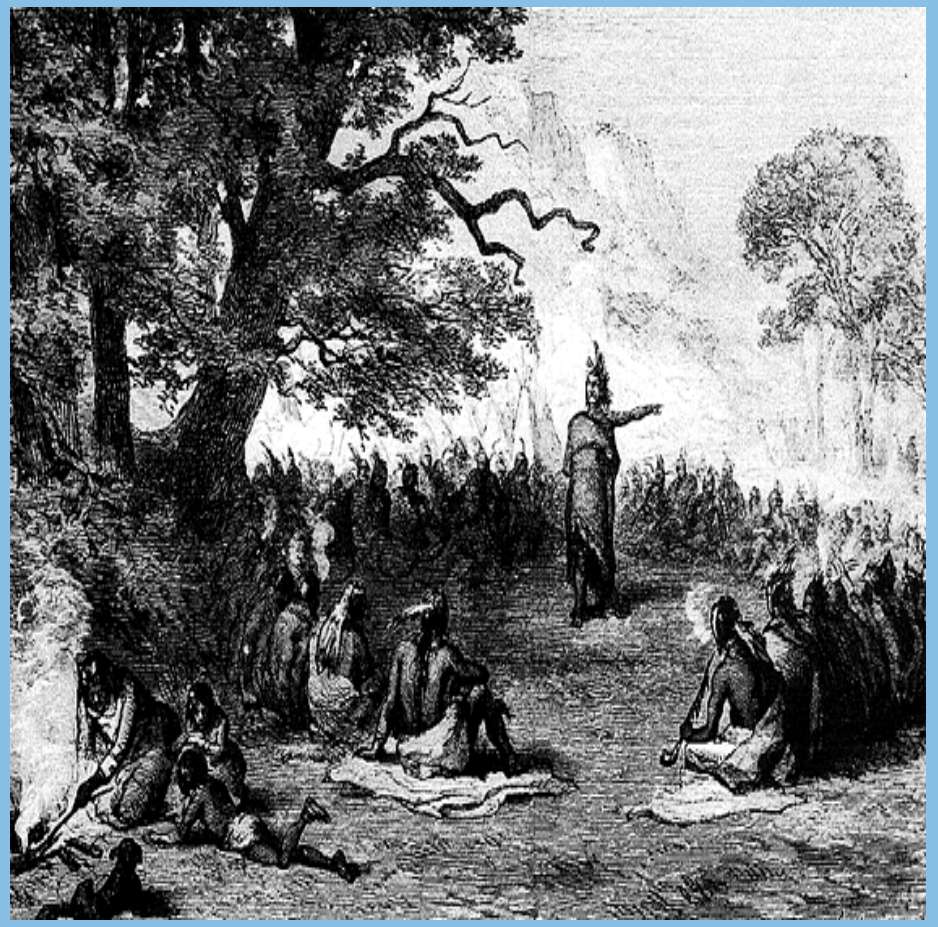
- Large DNA virus: Variola major
- Previously found naturally world-wide
- Altering human events for over 10 000 years
- Introduced to New-World by Spanish
- Currently virus found in only two places:
  - CDC (Atlanta Georgia)
  - Institute of Virus Preparations (Moscow)

# Smallpox: Biological Weapon

When was the first use of smallpox as a biological weapon?

# Smallpox

- New England in 1763 (Pontiac's Rebellion)
- British soldiers distributed blankets from small-pox infested blankets
- ½ of population died



# Smallpox: Mechanism

- 7-17 days incubation
  - Rash begins at 10 – 14 days
- Person-to-person spread --- Highly Contagious
  - Contaminated clothing or bedding
  - Aerosol
  - Up to 10 – 20 Second generation cases for each primary
  - Most infective while rash present
- Enters body through Oral/Nasal cavities
  - Travels to regional lymph nodes
  - Viremia leads to seeding of skin and all organs

# Smallpox: Symptoms

- Three Phases:
  - Incubation
  - Prodromal Illness
  - Fulminant Infection

# Smallpox: Incubation

- Infection through oral / respiratory
- Multiplication in regional lymph nodes
- Asymptomatic viremia at 3-4 days
- Further multiplication in spleen, marrow, lymph nodes
- Secondary viremia at 8 days

# Smallpox: Prodrome

- High fever
- Malaise
- Vomiting
- Headache
- Backache
- myalgia
- Lasts 2-3 days

# Smallpox: Fulminant Infection

- First lesions appear as papules / erosions on mouth and posterior pharynx
- Cutaneous eruption as macules become raised and indurated over several hours
- Firm, pearly, umbilicated vesicles over the next few days
- During the second week vesicles become pustular and confluent
- At 8-14 days lesions begin to dry with thick scabs and scarring

# Smallpox: Complications

- Blindness
- Osteomyelitis
- Arthritis
- Encephalitis
- Bronchitis
- Pneumonia
- Pulmonary Edema
- Sepsis
- Death

# Smallpox: Diagnosis

- Suspect when seeing high fever, characteristic rash, and severe illness
- Laboratory confirmation important:
  - Taken by recently vaccinated individual
  - Opens lesion to obtain fluid
  - Electron microscopy

# Diagnosis???

# Chickenpox

- Denser in trunk than face
- Lesions more superficial
- Never on palms / soles
- Lesions at various stages

# Smallpox: Treatment

- Supportive care
- Vaccinate all exposed patients and staff
  - (single dose in childhood does not confer lifelong immunity)
- Antivirals under investigation
  - Cidofovir (Nucleoside analogue)

# Smallpox: Vaccination

Describe the evolution of the smallpox vaccine.

# Smallpox:Vaccination

- Oldest of all Vaccines
- From 1000BC smallpox infected material used to confer immunity
- Jenner (1796)
  - Vaccination for smallpox using cowpox virus (Vaccinia)
- Last natural smallpox in North America 1949
- Last immunizations 1980

# Biological Agents: Smallpox

Why is the vaccine contraindicated in HIV / Immunosuppressed?

Should you vaccinate them anyways?

# Smallpox: Vaccination

- Vaccination of immunosuppressed
  - Vaccine can cause Vaccinia
  - Vaccinate immunosuppresed if truly exposed, can give Vaccine Immune Globulin (VIG) at same time.

# Smallpox:  Infection Control

What measures should be taken for infection control?

# Biological Agents

- Agent?
- Mechanism?
- Symptoms?
- Treatment?

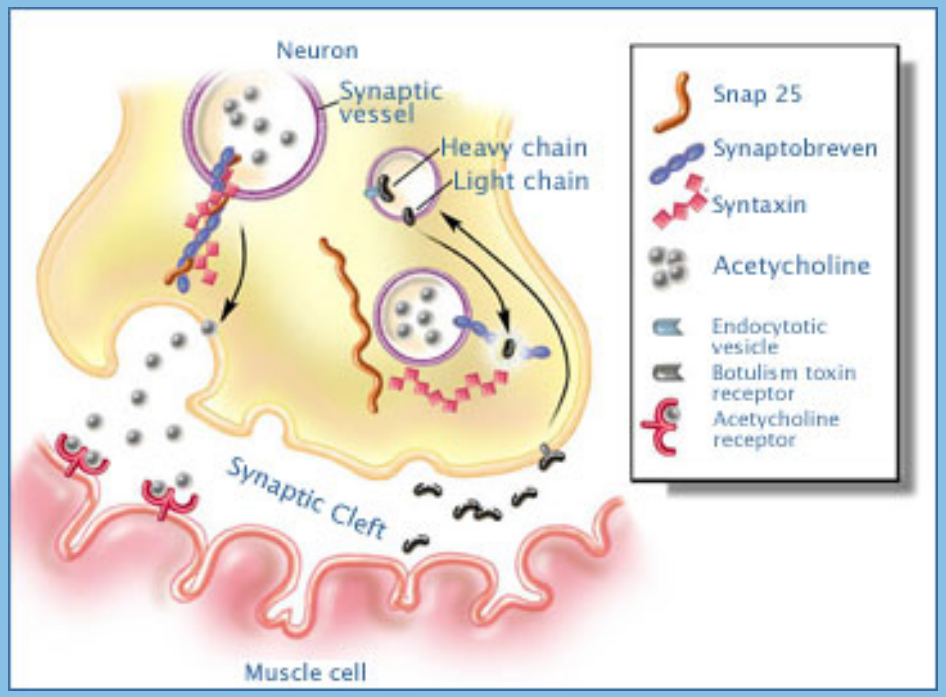
# Biological Agents: Botulism

- Toxin of Clostridium botulinum bacteria
- Clostridium botulinum
  - Anaerobic
  - Gram +
  - Spore forming
- Found globally in soil
- Spores very hardy:
  - Survive a wide range of temperature
  - Produce toxins in oxygen poor/acidic/low glucose

# Botulism Toxin

Describe the mechanism of botulism toxin.

# Botulism: Mechanism




- Blocks ach containing vesicle from fusing with terminal membrane of motor neurons.
- Flaccid paralysis
- Paralysis of diaphragm and muscles of airway

# Botulism

- “Acute afebrile descending paralysis, with clear sensorium”
- Symptoms begin 2h to 2d after exposure
- Initial symptoms are cranial nerves:
  - Vision changes / ptosis
  - Difficulty swallowing
  - Dysphagia
  - Dysphonia
- No sensory changes
- If untreated death results from respiritory paralysis

# Botulism: Transmission

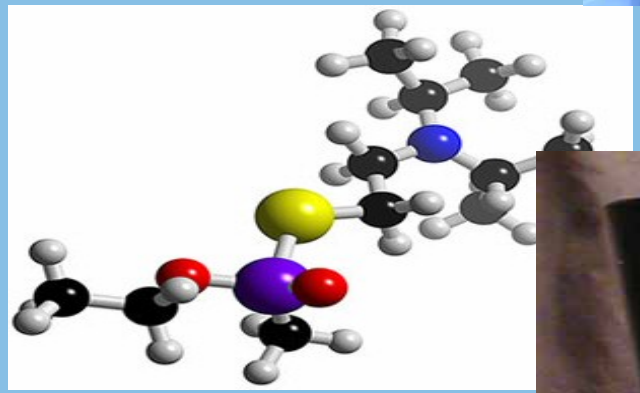
How is botulism usually transmitted naturally?

How could botulism be transmitted by terrorists?

# Botulism Transmission

- Naturally
  - Contaminated foods
  - Wound botulism
  - Cannot enter through intact skin
- Terrorism
  - Likely aerosolized
  - Not transmitted person-to-person

# Relative Toxicity




- Which of the following is the most toxic?
  1)Sarin
  2)VX
  3)Botulism Toxin
  4)Cyanide

# Relative Toxicity

- Botulism most toxic substance known
- 100,000 x more toxic than Sarin
- 15,000x more toxic than VX
- One gram can kill up to 1 million people

# Botulism Treatment

Which antibiotic would be used in the case of a terrorist attack using botulism?

# Botulism: Treatment

- No antibiotics
- Supportive care (often mechanical ventilation)
- Antitoxin:
  - Must be given in first 72 hours
  - Neutralizes toxin before it binds to Ach receptors
  - Slows progression but does not reverse disease
  - Equine derived
- Recovery is slow:  Axon regrowth.

# Biological Agents

Questions?

# Short Quiz

# Question 1

- Which of the following can propagate by person-to-person spread?
  - Anthrax?
  - Smallpox?
  - Hemorrhagic fever?
  - Plague?
  - Botulism?
  - Tularemia?

# Question 1

- Which of the following can propagate by person-to-person spread?
  - Anthrax
  - Smallpox
  - Hemorrhagic fever
  - Plague
  - Botulism
  - Tularemia

# Question 2

- Which of the following should be treated with antibiotics?
  - Anthrax?
  - Smallpox?
  - Hemorrhagic fever?
  - Plague?
  - Botulism?
  - Tularemia?

# Question 2

- Which of the following should be treated with antibiotics?
  - Anthrax
  - Smallpox
  - Hemorrhagic fever
  - Plague
  - Botulism
  - Tularemia

# Question 3

- Which of the following have a currently available vaccine?
  - Anthrax?
  - Smallpox?
  - Hemorrhagic fever?
  - Plague?
  - Botulism?
  - Tularemia?

# Question 3

- Which of the following have a currently available vaccine?
  - Anthrax
  - Smallpox
  - Hemorrhagic fever (Yellow fever only)
  - Plague
  - Botulism
  - Tularemia

# Question 4

- Which of the following have a currently available anti-toxin?
  - Anthrax
  - Smallpox
  - Hemorrhagic fever (Yellow fever only)
  - Plague
  - Botulism
  - Tularemia

# Question 4

- Which of the following have a currently available anti-toxin?
  - Anthrax
  - Smallpox
  - Hemorrhagic fever
  - Plague
  - Botulism
  - Tularemia

# Bioterrorism for Pharmacists Questions??


## Jeffrey Michael Franc

MD, CCFP.EM, Dip Sport Med, EMDM
Associate Clinical Professor of Emergency Medicine
University of Alberta

Visiting Professor in Disaster Medicine
Università degli Studi del Piemonte Orientale "Amedeo Avogadro"
Novara, Italy

Medical Director Emergency/Disaster Management
Alberta Health Services



UNIVERSITY OF ALBERTA

# Chemical Agents

# Chemical Agents

- Most of what we know is anecdotal
  - Much is military, >60yrs old
- Most chemical exposures are industrial
  - 70% occur in fixed facility
    - A plan is usually in place
  - 96% involve a single known substance
- Terrorism chemical events different
  - Substance not known.

# Chemical Agents: Why

- Exert effects quickly
- Response actions may extend for hours
- Lives may be saved or lost in initial minutes
  - Antidotes must be readily available
  - Often no time for specialized “teams”

# Chemical Agents:  Scenario

- Indicators often sudden and visible (0vert)
- Clouds of smoke without fire
- Multiple victims with same symptoms
  - 50% will arrive in first one hour.

# Chemical Agents: Decon

- Principles of triage, extraction, decon are not evidence based.
- Current best practice is soap and water.
- Use of bleach solution fallen out of favor
- On-site decontamination preferred.
- If no water available there is a commercial “reactive skin decontamination lotion”

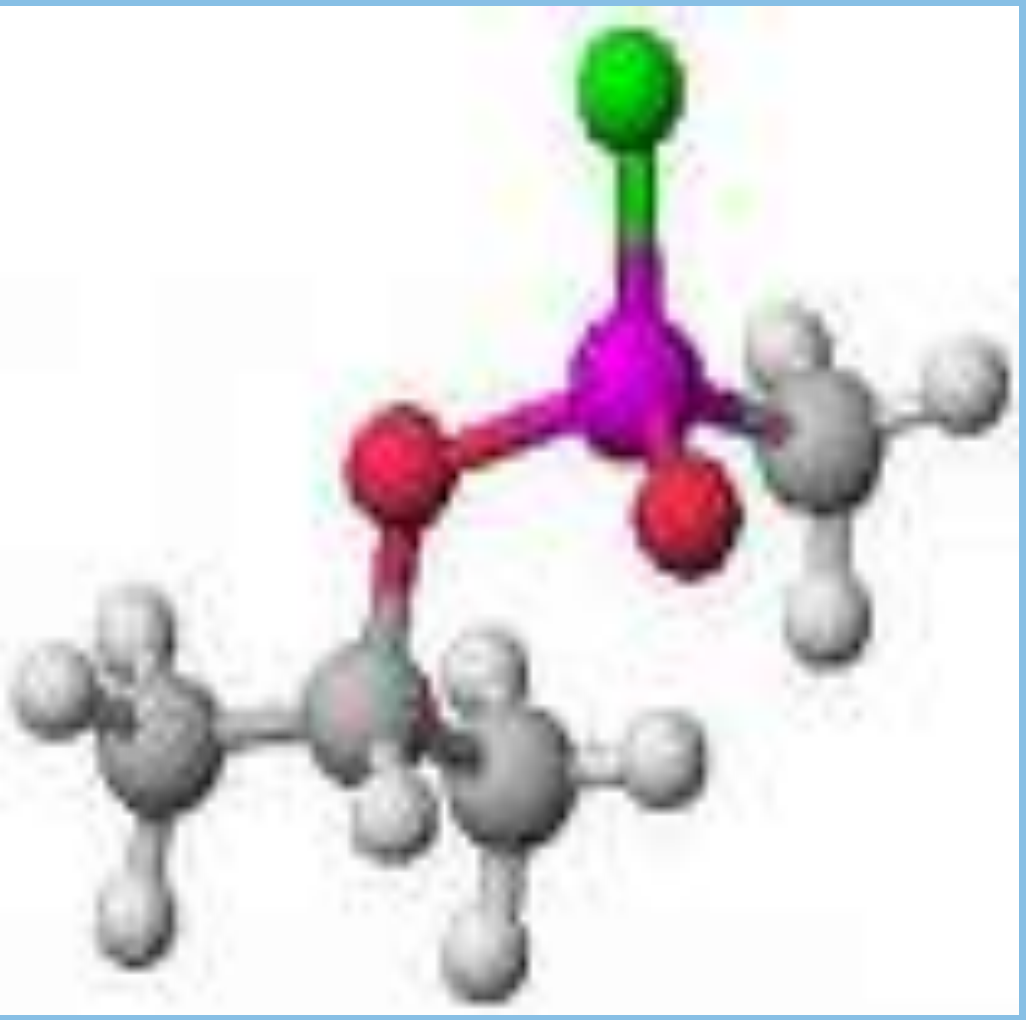
# Chemical Agents: Decon

- Tent should have three lanes:
  - Ambulatory
  - Non-Ambulatory
  - Health care providers

# Chemical Agents: Classification

- Nerve agents
- Vesicant agents
- Choking / Pulmonary agents
- Blood agents (cyanide)
- Others
  - Biotoxins
  - Caustics
  - Incapacitating agents
  - Long acting anticoagulants
  - Etc...

# Chemical Agents



- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Chemical Agents: Nerve Agents

- Tabun, sarin, soman, vx
- Mechanism:
  - Hyper stimulation of Ach Receptors
- Symptoms:
    - Nicotinic: Weakness, HTN, fasciculations, tachycardia
    - Muscarinic:  diaphoresis, incontinence, miosis, BRONCHORHEA, emesis, lacrimation.
- Treatment:
  - Skin decontamination
  - PPE with butyl rubber gloves.
  - Atropine:  for muscarinic effects
  - Oximes: (2-pam, pralodoxime)
    - Reactivate acetylcholinesterase
    - Must be given before aging (irreversible binding).

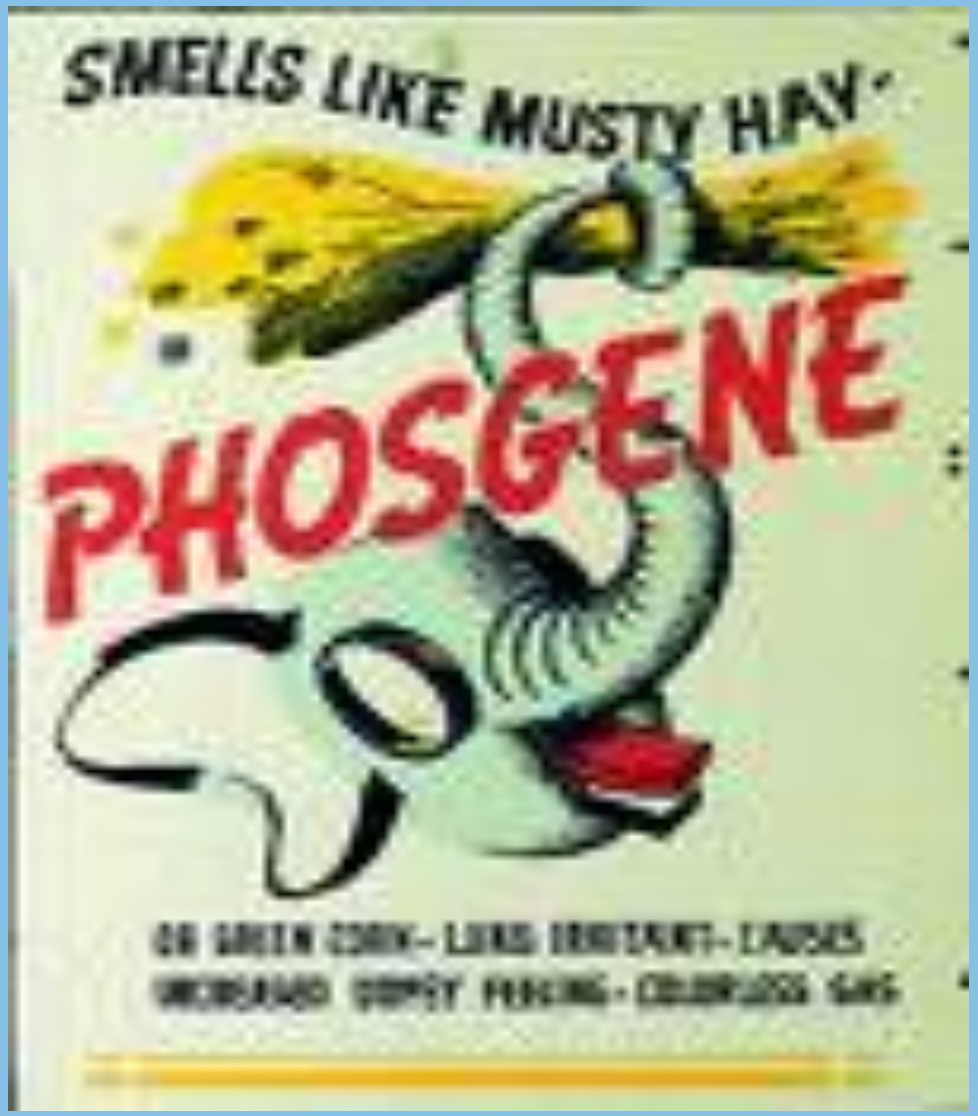
# Chemical Agents

- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Chemical Agents: Vesicants

- Mechanism:
  - Alkylating agents, interfere with DNA synthesis
- Symptoms:
  - Vesicals occur 2-12hrs after contact (irreversible)
  - Mustard gases (smells of mustard / garlic)
  - Lewisite (colorless, may smell of geraniums)
- Treatment
  - Flush skin and eyes
  - Watch for leukopenia
  - For lewisite:  consider BAL if severe (shock).
- Prognosis
  - Visual dysfunction usually resolves
  - Skin burns usually partial thickness but heal slowly
  - Fluid losses less than thermal burns
  - If asymptomatic at 24 hrs d/c home.

# Chemical Agents

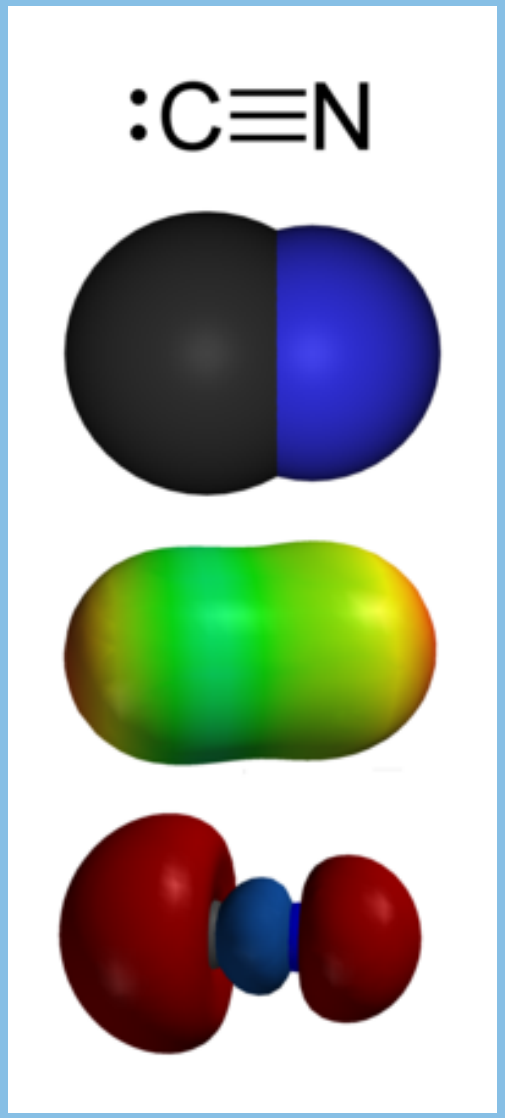



- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Chemical Agents: Respiratory

- Phosgene (mowed hay), Chlorine (bleach)
- Mechanism:
  - React with alveolar water to form HCL and free radicals
- Symptoms:
  - Multiple patients with pulm symptoms
  - Immediate tissue damage; symptoms at min to hours
  - Dyspnea, usually due to edema, bad prognosis if occurs early.
- Treatment:
  - Treat like asthma
    - Aerosols, steroids, intubate if needed
  - If asymptomatic 8-24 hours after exposure d/c home.

# Chemical Agents




- Agent?
- Mechanism?
- Symptoms?
- Treatment?

# Chemical Agents: Cyanide

- Mechanism:
  - -CN binds to iron (mitochondrial cytochrome-oxidase ferric iron)
  - “Uncouples oxidative phosphorylation”
- Symptoms
  - CNS and heart are most sensitive (Hyperpnea, diaphoresis, sweating, seizure
  - Collapse in 30 sec, death in 6-8min
  - May smell of bitter almonds (50%)
- Treatment
  - Inhaled amyl nitrate: induce methemoglobinemia
  - IV Sodium Nitrate: induce methemoglobinemia
  - Sodium thiosulfate:  Creates thiocycanate (excreted by kidney).
  - Hydroxycobalamine combines with -CN forming cyanocobalamine.

# Chemical Agents

Controversy:  Decontamination of ambulatory patients?

# Chemical Agents: Decontamination

- In the past all exposures were decontaminated.
- In some centers, ambulatory asymptomatic patients are not decontaminated…
  - Likelihood of being a harm to others is small.

# Chemical Agents

Questions?

# Explosives

# Explosions

What was the largest non-nuclear explosion in history?

# Explosives: Hint..

# Explosives

- 1917.  Halifax
- Collision of Imo and Mont Blanc
  - 35 Tonnes Benzene
  - 200 tonnes TNT
  - 300 Rounds Ammunition
- 2000 Deaths
- 9000 Injuries
- One ship blown 1 ½ km into the air
- 2.5km of city leveled
- Shattered windows 100 km away

# Explosives: Mechanism

- Two types of conventional explosives
  - Ordinary, slow release of energy
    - eg.  Gunpowder
  - High Explosives, fast release of energy
    - eg. TNT, Diesel fuel + Nitrogen fertilizer

# Explosives: Mechanism

- Pressure Pulse:
  - Rapidly expanding gases
  - Travels faster than speed of sound
  - Expands in all directions
  - Leading edge called Blast Front
  - Magnitude of shock wave at blast front is called “positive phase impulse”
    - Important marker of severity.

# Explosives: Mechanism

- Overpressure
  - Pressure higher than atmospheric
  - Duration less than .1 seconds
  - Severe overpressure causes “shock wave”
    - Magnitude of shattering effect is called brissance
- Pressure waves are 20x stronger in closed space
- Closed space injuries:
  - Higher mortality rate
  - Lower number of victims
  - Higher incidence pulmonary injury

# Explosives: Mechanism

- Underpressure:
  - Sudden drop in pressure causes underpressure
  - Underpressure causes blast wave up to 1000 km/h
- Then wave deteriorates to acoustic wave.

# Explosives: Mechanism

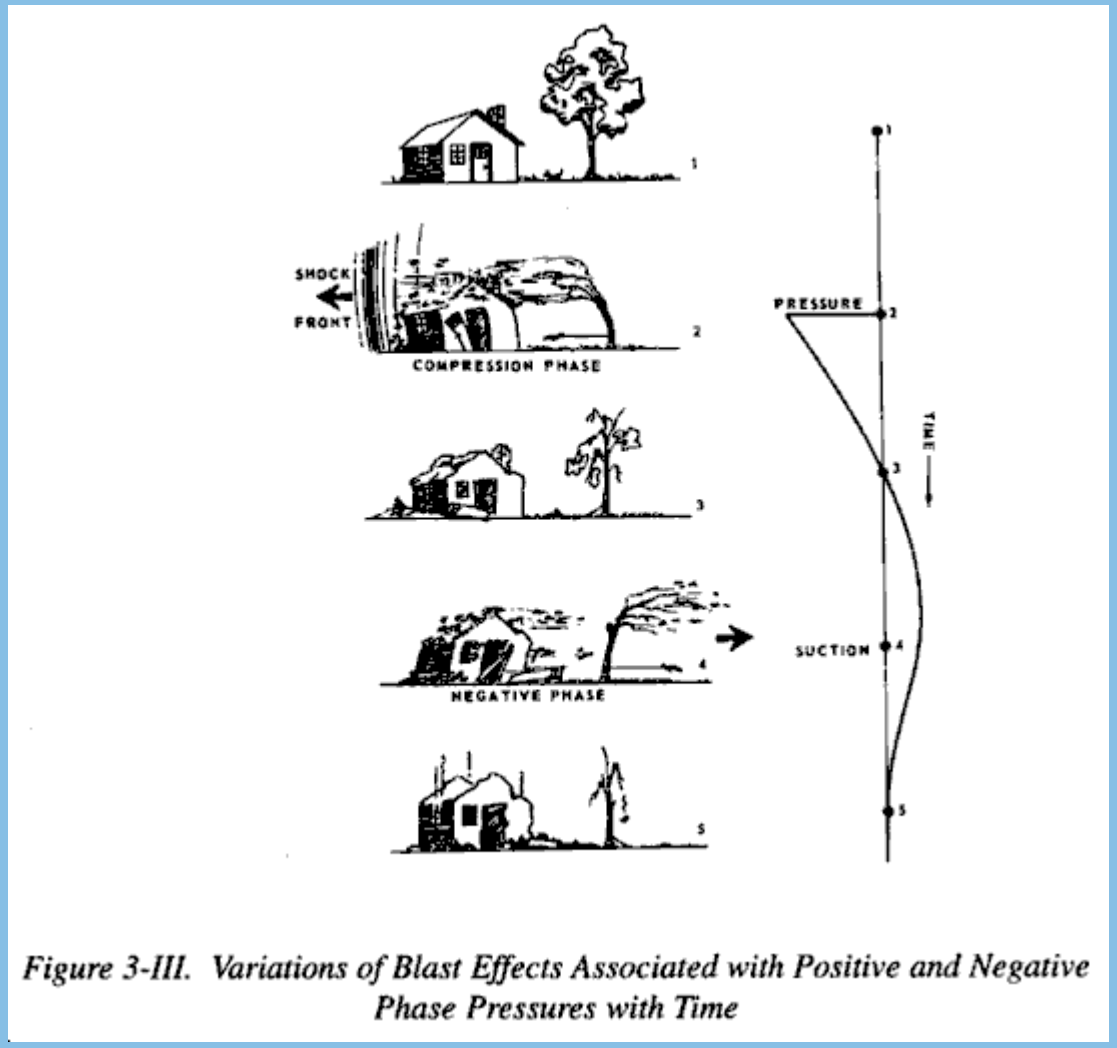



*Figure 3-III. Variations of Blast Effects Associated with Positive and Negative Phase Pressures with Time*

Why is this important???

- Overpressure causes primary blast injury
- Underpressure causes secondary / tertiary injury.

# Explosions

What is...
Primary Blast Injury?
Secondary Blast Injury?
Tertiary Blast Injury?

# Blast Injuries: Classification

- Primary:
  - Direct effect of overpressure forces
  - Damage to air containing organs
    - Ears, lungs, intestine
  - Most victims of primary blast injury are killed immediately

# Explosions: Classification

- Secondary:
  - Missile Effects
    - Casing of device
    - Glass, metal, etc
- Tertiary
  - Deceleration of body
- Quaternary (miscellaneous)
  - Burns, inhalation, crush.

# Explosions: Treatment Basics

- Early and aggressive resuscitation is the key.
- Of initial survivors, most complications result in late deaths (>6hrs)
- Secondary / Tertiary / Quaternary injuries are managed as usual ED practice.
- Of those that survive, few will have primary blast injury
  - However, greatest potential for avoiding late deaths is meticulous management of primary blast injury thorax.

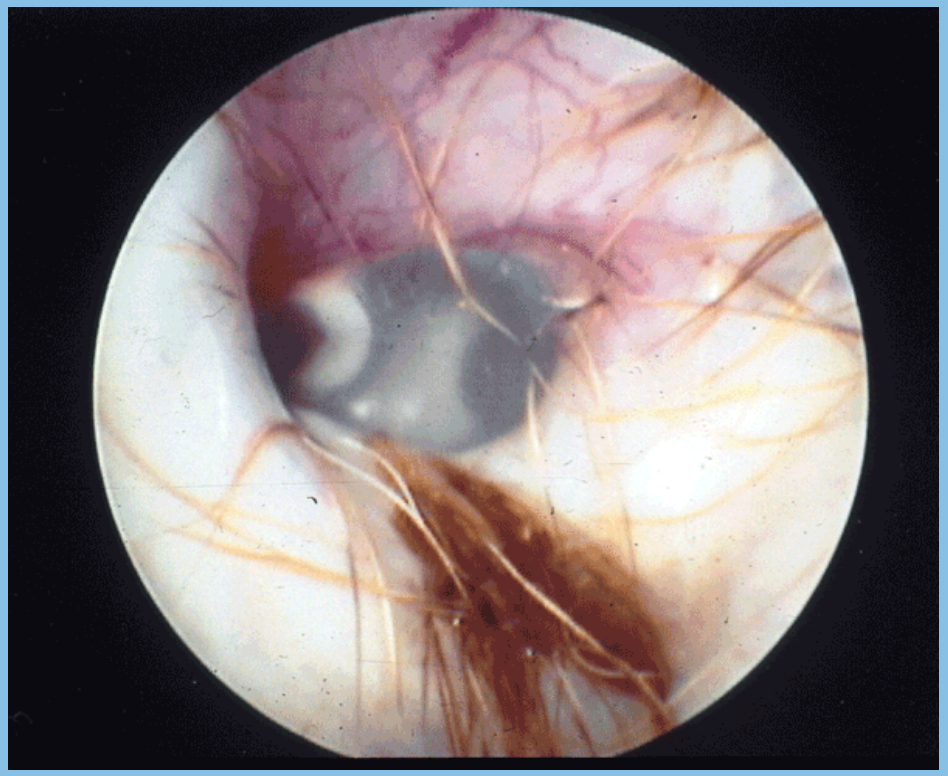
# Explosions: Primary Blast Injury

- There are four distinct mechanisms:
  - Irreversible work:
    - Blast loading
      - Stress wave:  damage due to peak amplitude
      - Shear wave: Damage due to velocity
  - Inertial effects:
    - Differential acceleration of different densities
  - Spalling:
    - Disruption of boundaries between densities
  - Implosion:
    - Forceful compression of gas bubble

# Explosions: Mechanism Example

- Primary blast injury of lung:
  - Irreversible work:
    - Blast wave strikes torso (blunt trauma)
    - Compression of chest wall
  - Inertial effects:
    - Differential acceleration of parenchyma and airway
  - Spalling:
    - Disruption of capillary alveolar interface
  - Implosion:
    - Compression and re expansion alveoli

# Explosions



- Injury?
- Mechanism?
- Symptoms?
- Treatment?

# Explosions: Auditory Injury

- Mechanism:
  - Primary blast injury
- Symptoms:
  - Tinnitus, otalgia, Aural fullness
  - Vertigo?  Suggests perilymph fistula:
  - TM is ruptured or multiple “punched out” lesions
- Treatment:
  - Despite initial severe symptoms most recover spontaneously (80%)
  - Urgent ENT surgery if suspect perilymph fistula.
  - If TM rupture with no other symptoms/signs of injury and normal CXR, observe 6hr, likely d/c home.

# Explosions

- Injury?
- Mechanism?
- Symptoms?
- Treatment?

# Explosions: Blast Lung

- Mechanism:
  - Primary blast injury
    - Pulmonary Hemorrhage
    - Pulmonary Edema
    - Disruption of alveoli
    - Alveolar / capillary fistula
    - Air Embolism
- Symptoms
  - Resembles ARDS and pulm contusion
  - Sx may be delayed 24-48 hours
    - Dyspnea, cough, hemoptysis, chest pain.
  - Xray: pulmonary opacity butterfly distribution

# Explosions: Blast Lung

- Treatment:
  - Major cause of death in those that survive initial blast
  - Aggressive treatment markedly improves prognosis
    - Treat as usual ARDS / Pulmonary contusion
    - High risk of barotrauma
    - Avoid positive pressure ventilation if possible
    - Avoid excess fluids
    - Regional anesthetics for surgeries
  - Consider…
    - Permissive hypercapnia??
    - Intermittent mechanical ventilation / CPAP??
    - Prophylactic chest tubes??
    - High frequency jet ventilation??
    - Hyperbaric treatment??

# Explosions: BLISS

Table 1. BLI S

PaO 2/FIO 2 <

Chest radiograph

Bronchial pleural fistula

Pizov et al. Ch

Sheet1

## Table 1. BLI Severity Score

| | Severe BLI | Moderate | Mild BLI |
|---|---|---|---|
| **PaO2/FIO2** | < 60 | 60 to 200 | > 200 |
| **Chest radiograph** | Massive bilateral lung infiltrates | Bilateral or unilateral lung infiltrates | Localized lung infiltrates |
| **Bronchial pleural fistula** | Yes | Yes/No | No |

Pizov et al. Chest 1999

# Explosions: BLISS

- Mild:
  - No chance developing complications
- Moderate:
  - 33% chance developing complications
- Severe:
  - All get ARDS or die

# Explosions


- Injury?
- Mechanism?
- Symptoms?
- Treatment?

# Explosions: Abdominal Injury

- Mechanism:
  - Primary blast injury
  - Injures gas containing organs primarily
  - Usually small multi focal intramural hematoma in ileocecal / colonic area
  - Uncommon
- Symptoms:
  - Abd pain, nausea, vomiting, tenderness, peritonitis
  - May be delayed 48hr. Difficult to predict
- Treat:
  - Usual ED management
  - Delay colonoscopy.

# Explosions: Miscellaneous

- Cardiovascular:
  - Immediately post blast most victims are hypotensive and bradycardic
  - Vagally mediated.
- MSK:
  - Most are secondary / tertiary
- CNS
  - Most are secondary / tertiary
  - A major cause of immediate and delayed mortality
  - May include arterial air emboli (Primary)

# Explosion: Controversy

Does an normal TM rule out significant Primary Blast Injury?

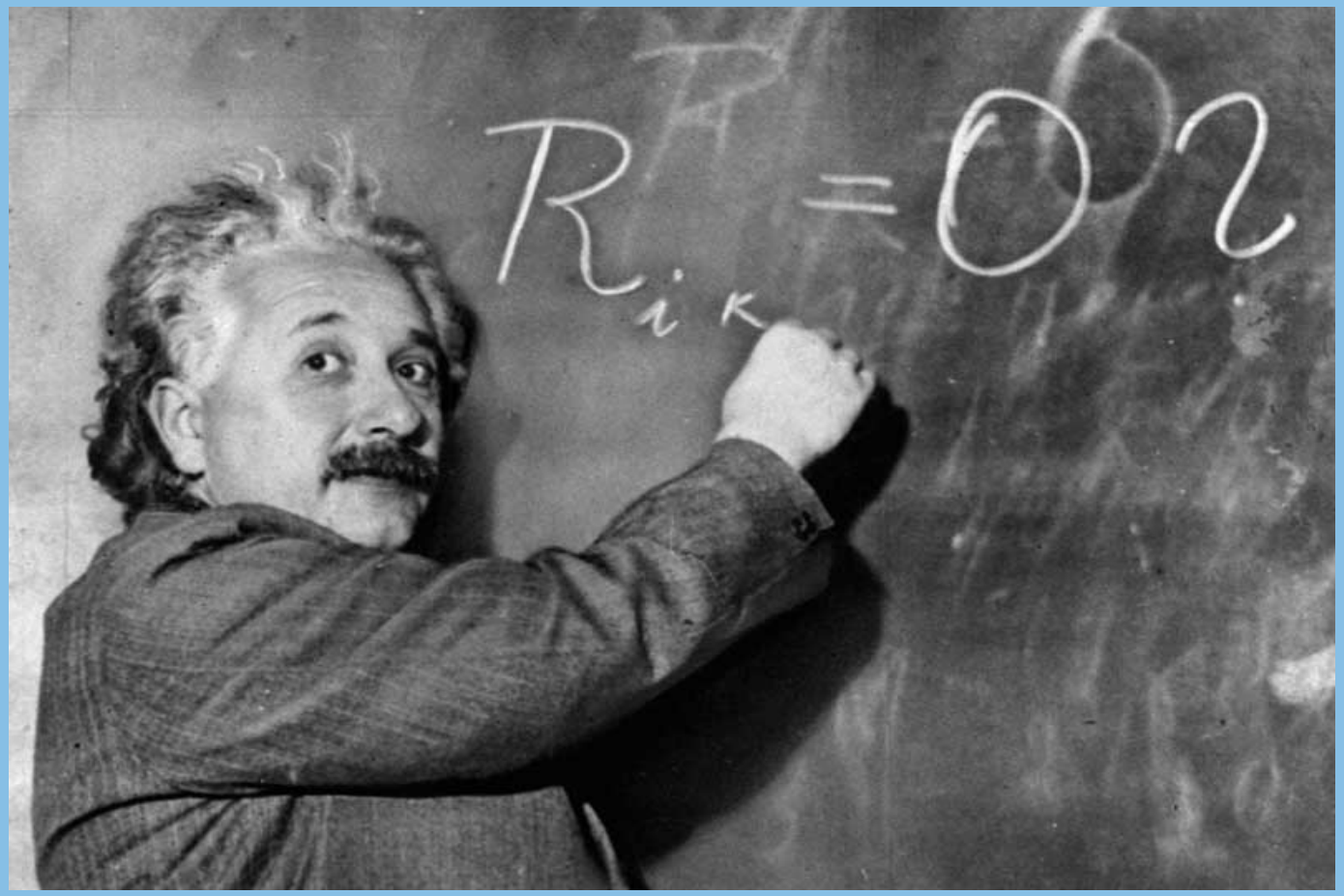
# Explosions: Controversy

- Initially this was thought to be true:
  - Leibovici et al.  Ann Emerg Med 1996
- However...Leibovici et al. J Trauma 1999
  - 647 Survivors of blast injury
  - 9.6% of Primary Pulmonary injuries had normal TM's

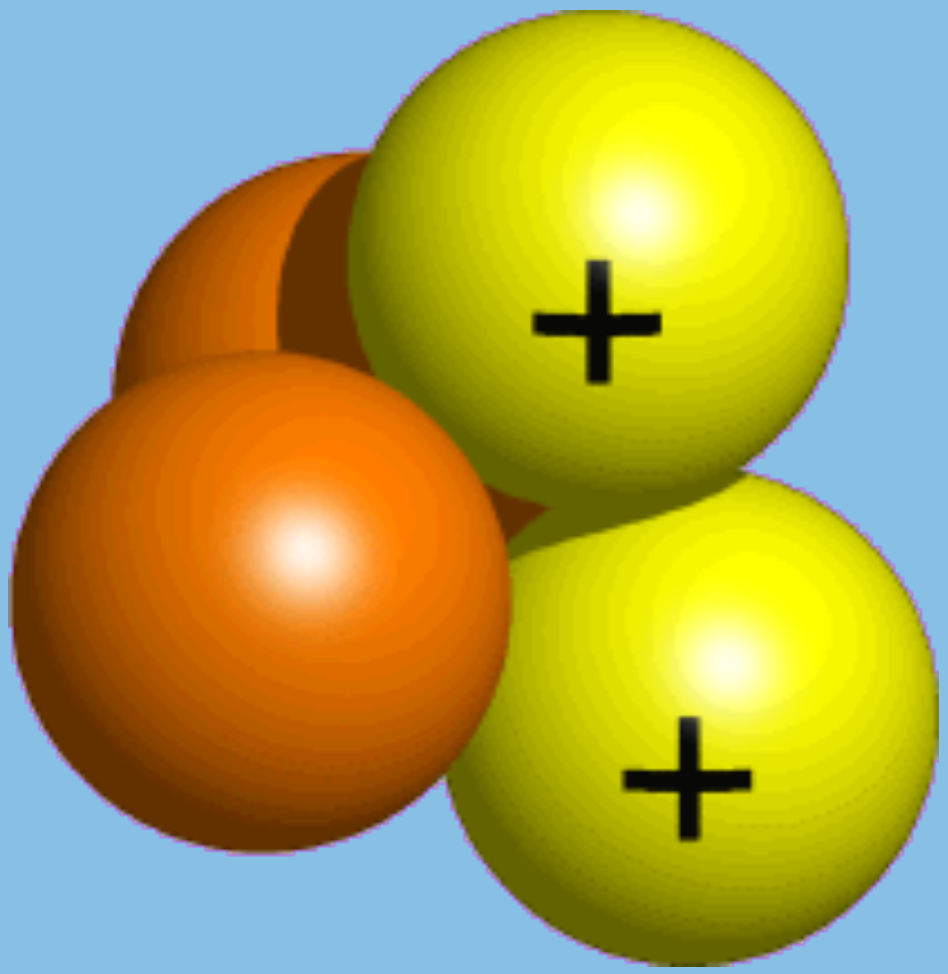
# Explosions

Questions?

# Radiation



# Radiation



- Agent?
- Description?
- Penetration?
- Sources?

# Radiation: Alpha Particles

- Description:
  - Helium Nucleus
  - 2 protons, 2 neutrons
- Penetration:
  - Shielded by clothing, paper, epidermis
  - Harmful if swallowed (give up large amount of energy in short distance)
- Source:
  - Uranium, plutonium, americium, radon

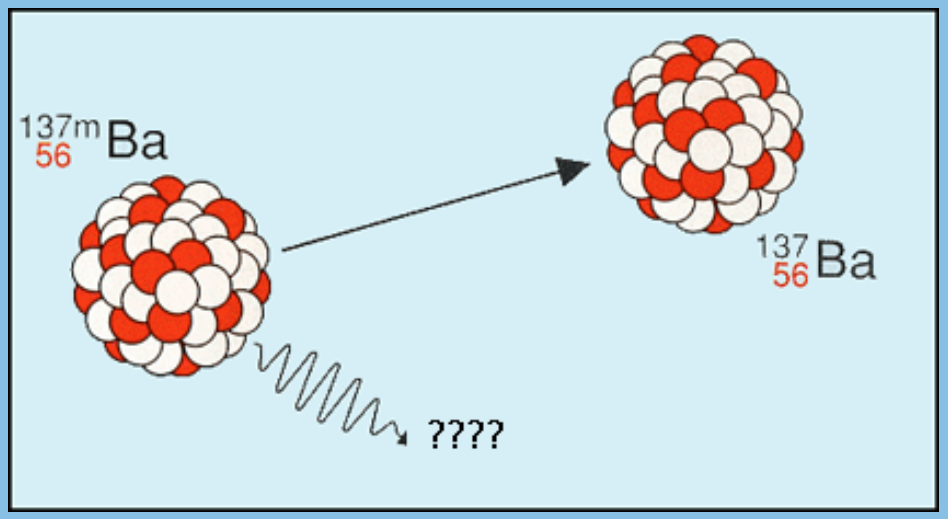
# Radiation

- Agent?
- Description?
- Penetration?
- Source?

# Radiation: Beta Particles

- Description:
  - An electron emitted from an unstable nucleus
- Penetration:
  - 1 meter in air
  - 1-2 cm into human tissue
  - Severe local damage to skin / bony prominences
  - Shielded by thin layer plastic, cloth, glass...
- Source:
  - Tritium, nuclear fallout, Radio strontium (reactor)

# Radiation

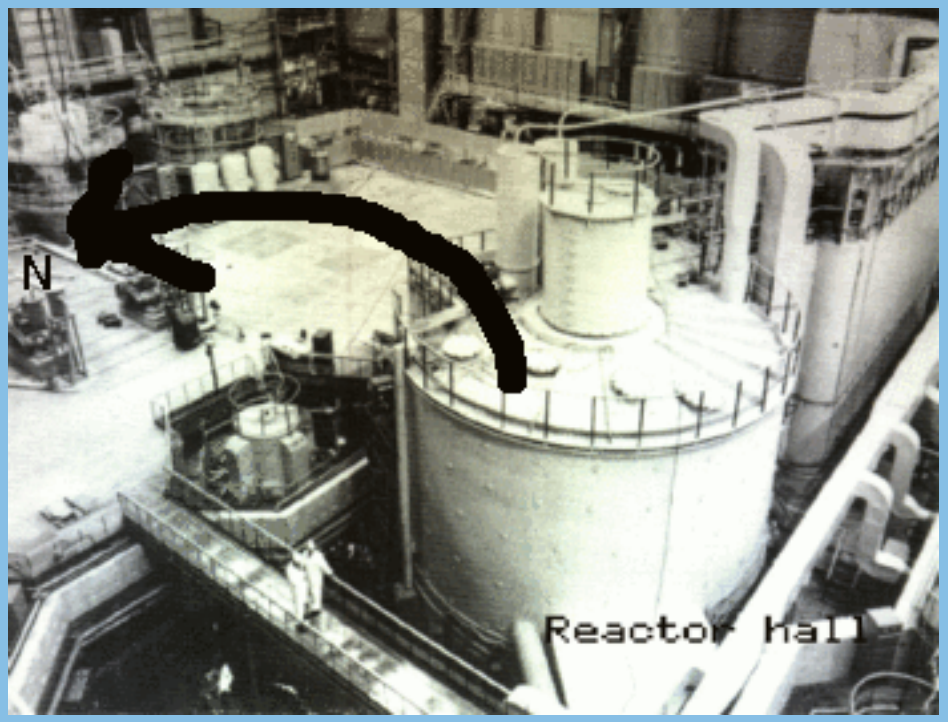



- Agent?
- Describe?
- Penetration?
- Source?

# Radiation: Gamma / Xray

- Description:
  - Photon (has no mass or charge)
    - Gamma from unstable nucleus
    - Xray: from outer electron shell
- Penetration:
  - Deep penetration to body and severe damage
  - 5cm lead to stop
- Source:
  - Radio cesium
  - Xray equipment

# Radiation

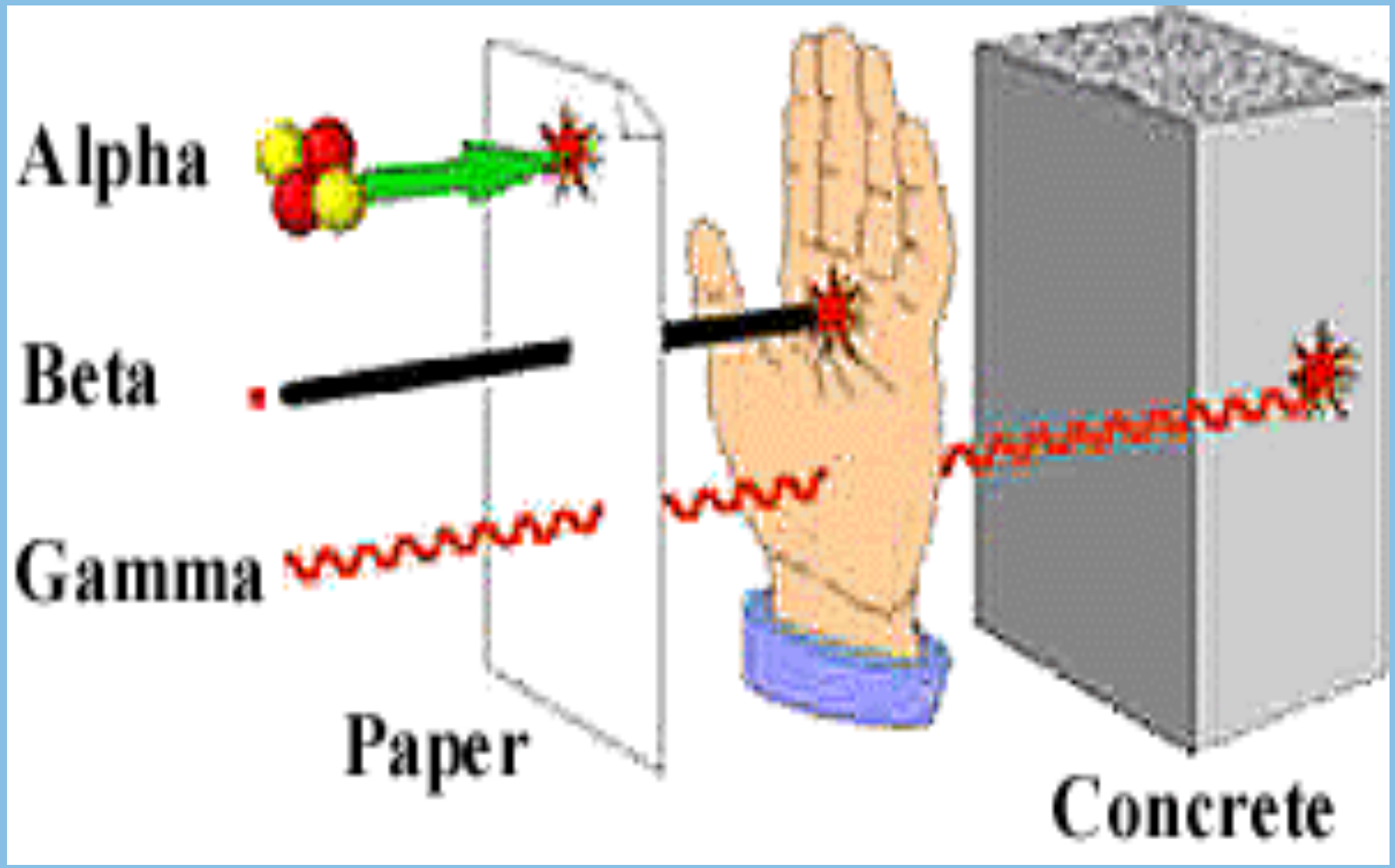



- Agent?
- Describe?
- Penetration?
- Source?

# Radiation: Neutron Particles

- Description:
  - Arises from unstable nucleus
- Penetration:
  - Deep penetration / Severe Damage
- Source:
  - Nuclear reactors

# Radiation: Penetration



# Radiation

How is radiation dispersed in a terrorist event?

# Radiation: Sources

- Radiation Emission Device
- Radiation Dispersal Device
- Sabotage of nuclear facilities
- Detonation of improvised nuclear device
- Detonation of stolen nuclear device

# Radiation: Exposures

- Four Forms of Exposure:
  1. Irradiation
  2. External Contamination
  3. Internal Contamination (ingestion)
  4. Incorporation
     - Inhaled or swallowed then absorbed into organs

# Radiation: Exposures

- Biological effects are Dependant upon…
  - Type of radiation
  - Duration of exposure
  - Shielding
  - Distance from source

# Radiation: Biological Effects

- Production of charged water molecules (Free - OH)
- Direct ionization of DNA
- Rapidly dividing cells are most sensitive
- Nonlethal doses may lead to malignant transformation

# Radiation: Clinical Syndromes

- Acute Radiation Sickness
- (ARS)

- Cutaneous Radiation Syndrome
- (CRS)

# Radiation: Acute Radiation Sickness (ARS)

- 1. Hematopoetic (dose > 2sv)
  - Lymphocytes are most sensitive to radiation
  - Destruction of bone marrow
  - Pancytopenia

# Radiation: ARS

- 2. Gastrointestinal (dose >6 sv)
  - Sloughing of GI mucosa
  - Nausea, vomiting, diarrhea
  - Usually fatal within 2 weeks

# Radiation: ARS

- 3. Cardiovascular / Central Nervous System
  - Dose > 20 sv
  - Immediate nausea, vomiting, ataxia, seizure
  - Due to diffuse microvascular leaking
  - Likely to be fatal

# Radiation: ARS

- Phase I (Prodrome)
  - Begins within first 48 hrs
  - Nausea, vomiting, fatigue, fever, resp distress, agitation
  - Last for minutes to days
  - Can be episodic
  - Early onset of prodromal symptoms marks poor prognosis

# Radiation: ARS

- Phase 2 (Latent Phase)
  - Asymptomatic
  - Lasts up to 3 weeks
  - Higher doses of radiation lead to shorter latent phase

# Radiation: ARS

- Phase 3 (Illness Phase)
  - Infection due to leukopenia
  - Bleeding due to thrombocytopenia
  - Diarrhea, electrolyte imbalance, altered LOC, Shock

# Radiation: ARS

- Phase 4 (Manifest Phase)
  - 
    Either...
    - Die
    - Get better

# Radiation: ARS

- Markers of severity:
  - 1. Time to onset of prodromal symptoms
    - Vomiting at <4h = Severe
  - 2. Lymphocyte count in first 48h
    - <500 = “Serious”
    - <1000 = “Moderate”

# Radiation: ARS

**TABLE 32.3 COMPLETE UNION OF SOVIET SOCIALIST REPUBLICS CLASSIFICATION OF CHERNOBYL VICTIMS[a]**

| Parameter | Fourth degree | Third degree | Second degree | First degree |
|---|---|---|---|---|
| Prodrome onset (h) | ≤0.5 (vomiting at 30 min, headache, fever) | 0.5–1 (vomiting, headache, subfebrile, transient hyperemia of skin) | 1–3 (vomiting) | >3 (general reaction) |
| Latent period (d) | 6–8 | 8–17 | 15–25 | >30 |
| Skin burns | 40%–90% | 6 severe, all died | Slight | Slight |
| Enteritis | 7–9 d | — | — | — |
| Lymphocytes/μL (3–6 d) | <100 | 100–200 | 300–500 | 600–1,000 |
| Granulocytes/μL | <500 (7–9 d) | <1,000 (8–20 d) | >1,000 (20–300 patients) in 15–20 d | 3,000–4,000 (8–9 d) |
| Platelets/μL | <40,000 (8–10 d) | <40,000 (10–16 d) | 40,000 (17–24 d) | 40,000–60,000 (25–28 d) |
| Total body radiation dose (Gy) | >6–12, 16 (600–1,200 rads, 1,600 rads) | 4.2–6.3 (420–630 rads) | 2–4 (200–400 rads) | 1–2 (100–200 rads) |
| Deaths/number of patients | 17/20 (Moscow, 10–50 d; 2 at Kiev, 4 at 10 d) | 7/23 (2–7 wk) | 0/53 | — |
| Clinical findings | General intoxication, fever, oral and salivary lesions, beta burns severe enough to cause death, >8–10 Gy of exposure, severe intestinal syndrome | High fever, infection, hemorrhage, severe skin injury | Infections, slight hemorrhage, elevated erythrocyte sedimentation rate | No severe skin change, moderate elevation of erythrocyte sedimentation rate |
| Estimate of survival | Unlikely | Probable with treatment | Possible without treatment | Probable without treatment |

Modified by Barabanova. Row items have been rearranged for temporal clarity.
[a]Barabanova related that categories for first and second degree injuries were actually slightly different in Radiation Emergency Assistance Center/training site (REAC/TS) newsletter, winter 1992.

# Radiation: CRS

- Due to direct exposure to Beta or Gamma
- May occur due to direct contamination of clothing.
- Appears similar to thermal burn
  - May be delayed onset (minutes to weeks)
  - Blistering and delayed necrosis
- May lead to vascular insufficiency, necrosis, ulcers
- Underlying bone necrosis may occur at bony prominences.

# Radiation

A patient is exposed to a Radiation Emission Device (RED) and arrives at your department.  What form of decontamination is necessary?  What from of isolation?

# Radiation: Ionizing

- Exposure to external ionizing radiation does not render a patient radioactive.
- No harm to others
- No decon
- No isolation

# Radiation: Ionizing

However...

# Radiation: Neutron

- High dose neutron radiation
- Patient may become weak beta / gamma source
- Unlikely to be any harm to others.

# Radiation

Same patient arrives, however, this time he has been a victim of a Radiation Dispersal Device (RDD). How is he decontaminated? Isolation?

# Radiation: Detection

- Multiple types specialized radiation detection devices
  - Monitoring Instruments
    - Radiation Survey Meters (“Geiger Counters”)
    - Newer digital radiation monitor units
  - Personal Radiation Dosimeters
    - Film Badges
    - Thermoluminescence  dosimeters
    - Pocket Dosimeters
  - Gamma Camera (nuclear med)

# Radiation:  External Contamination

- Unlike chemical contamination, Radiation decontamination is not usually an emergency.  Patient care takes precedence.
- Rescuers should wear PPE to avoid contamination (standard PPE is adequate)
- Take cotton swab of both nears for evidence
- Remove clothing will reduce exposure by 90%
- Water and soap
  - Cover contaminated wounds prior to decon

# Radiation: Contaminated Wounds

- Contaminated wounds:
  - High pressure NS
  - Remove shrapnel with instrument..NOT GLOVES
  - Wounds contaminated with Alpha particles are usually excised
  - Avoid aggressive surgical management

# Radiation: Internal Contamination

- Hasten Elimination and prevent incorporation
  - Prussian blue for cesium
  - Forced fluids for Tritium
  - Chelation for Plutonium
  - Iodine for radioactive iodine

# Radiation: Treatment

- Consider all symptomatic patients to be immunsuppressed:  Surgery should take place within 48 hours or be delayed until WBC recovers.
- Admit all symptomatic patients
  - Symptom control
  - May need colony stimulating factors
- Antibiotics for neutrapenic patients.

# Radiation

A patient states she has been exposed to radiation.  She is asymptomatic.  What do you do?

# Radiation: Asymptomatic Exposure

- IF....
  - Stable
  - Asymptomatic
  - Normal Labs
- Then...
  - D/c home
  - RTED if symptoms of ARS or CRS develop
  - Recheck Lymphocyte count in 24-48hrs

# Radiation

Questions?

# Nuclear

# Nuclear

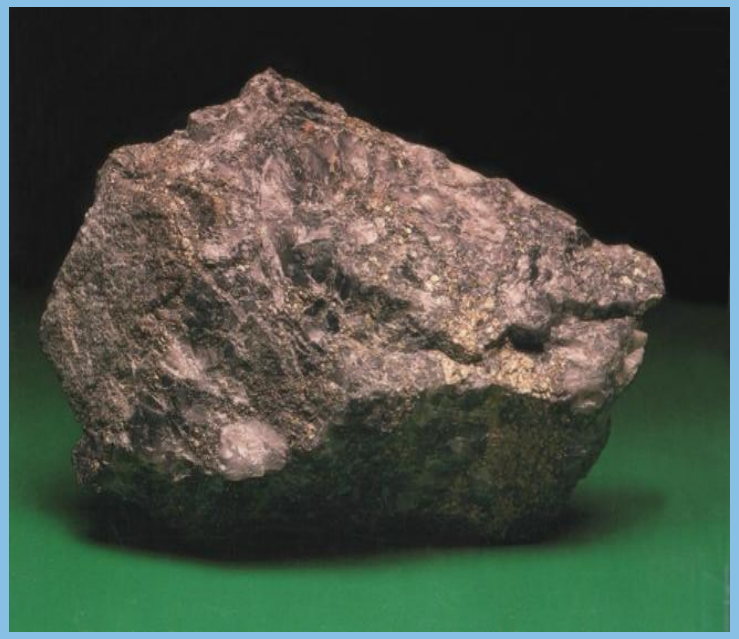
- Energy Distribution from Nuclear Detonation
  - 50% Blast
  - 35% thermal radiation
  - 4% Initial Ionizing radiation
  - 10% Residual Ionizing radiation
  - 1% Electromagnetic pulse

# Radiation: Sources

- Radiation Emission Device
- Radiation Dispersal Device
- Sabotage of nuclear facilities
- Detonation of improvised nuclear device
- Detonation of stolen nuclear device

# Nuclear: Improvised Device

How large must the device be?



# Nuclear: Improvised Device

- Critical mass U235 = 56 kg
  - As low as 15 kg in appropriate compression device
- Critical mass Pu239 = 11 kg
  - As low as 5 kg in appropriate compression device

# Nuclear: Tips

- First responders should turn around at 0.1 sv
- Shielding is the best protection
- Never look at the fire-ball
  - Blindness at 20 km daylight
  - Blindness at 50 km night
- 7 fold increase in time after detonation reduces exposure by 10 fold

# Nuclear: Treatment

- First responders should wear PPE
- Decontaminate outside ED if possible

# Nuclear

After the Three Mile Island incident, people in the surrounding communities requested Iodine treatment. Why? Is is necessary?

# Nuclear: Iodine

- Necessary only if radio-iodine was the offending agent
- Competitive blocking of Radioactive Iodide into the thyroid.
- May help prevent thyroid cancer (only).

# Nuclear

Questions?

# CBRNE Update for Emergency Physicians

Jeffrey Michael Franc-Law,
MD, CCFP.EM, Dip Sport Med, EMDM candidate
Assistant Clinical Professor of Emergency Medicine
University of Alberta

# Questions?

# Chemical

## Riot Control Agents

# Riot Control Agents

- Multiple agents are used.  Commonly known by their NATO designations
  - 1-trichloroacetic (CN) “mace”
  - O-trichloroethane matrimonially (CS)
  - Bromobenzylcyanide (CA)
  - Dibenz (b,f)-1:4-oxyzepine (CR)
  - Oleoresin Capsaicin (OC) “pepper spray”

# Riot Control Agents

- Characteristics common to all agents
  - Sensory irritation leads to severe discomfort
  - Quick onset of action
  - Short duration of effects
  - High safety profile

# Riot Control Agents: Physics

- All  are liquids or solids, not gasses
  - Dispersed as fine particles or droplets
- CS is most common agent in use today
- Commercial personal protection pepper spray is often OC +CN

# Riot Control Agent: Pathology

- Symptoms start at 1 min
- Last approximately 30 min
- Eyes
  - Severe blepherospasm
  - Visual acuity is normal
  - Effects disappear in 20 min
  - May have conjunctivitis x 24 hours

# Riot Control Agents: Pathology

- Nose
  - rhinorrhea
- Skin
  - Erythema, burning, tingling
  - Vesicles similar to thermal burns
- Pregnancy
  - No significant effect

# Riot Control Agents: Pathology

- Lung
  - Burning sensation, bronchospasm, coughing, dyspnea.
  - High doses may lead to pulmonary edema
  - Worsens Asthma or COPD
  - Does not cause abnormal spirometry, hypoxia, or hypoventilation in normal patients (Cucanell et al.  Fed Proc.)

# Riot Control Agents: Decon

- Exit scene of exposure
- Remove clothing.  Do not pull clothing over head (cut off)
- Wash victim with soap and water
  - Wetting of skin may temporarily worsen severity of burning
- Always decon before helicopter transport (avoid immobilization of crew)

# Riot Control Agents: Treatment

- Eye
  - Blow dry air into eyes to remove particles BEFORE irrigation
  - Saline irrigation
  - Slit lamp exam
    - Remove any FB
    - Document corneal injury

# Riot Control Agents: Treatment

- Lung
  - Inhaled Beta-agonists
- Skin
  - Brush solids off of skin
  - Irrigate with water (not bleach solution)
  - Treat as thermal burn

# Riot Control Agents: Disposition

- Admit patients with any pulmonary symptoms
  - Pulmonary edema may occur late

# Riot Control Agents

Questions?

# CBRNE Update for Emergency Physicians

Jeffrey Michael Franc-Law,
MD, CCFP.EM, Dip Sport Med, EMDM candidate
Assistant Clinical Professor of Emergency Medicine
University of Alberta

# Questions?