Respiratory Care Emergency Preparedness For Mass Casualty Events

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Learning Objectives:

- Identify infections capable of causing mass casualties and describe their etiologies, manifestations, diagnosis, management and prevention.
- Apply strategies and devices to prevent communication of infections to caregivers, patients and the environment.
- Identify chemical agents capable of causing mass casualties and describe their likely sources, effects, manifestations and management of chemically contaminated patients.

Learning Objectives:

- Identify the sources of mass casualty radiation events and describe the effects, manifestations and management of radiation injuries.
- Identify sources of blast injuries and describe the types of injuries, their manifestations and their management.
- Describe major types of natural disasters, their associated types of injuries, their manifestations and management.

Learning Objectives:

- Discuss problems associated with healthcare delivery in natural disasters, including those associated with transportation and destruction of physical facilities.
- Distinguish among conventional, contingency, crisis modes within a healthcare facility with respect to space, staffing, equipment and supplies.
- Describe preparations and response strategies for mass casualty situations with respect to respiratory care equipment and supplies, including oxygen and mechanical ventilators.

Mass Casualty Events

Definition

- Disaster - is what happened when a woman backed into a fan

Disaster

- Definition - a sudden calamitous event bringing great damage, loss, or destruction (Merriam-Webster)
- Types:
  - Natural disasters; e.g., pandemics, hurricanes, earthquakes, etc.
  - Man-made
    - pandemics
    - accidental; e.g.; industrial explosions
    - terrorism, which intends to injure and to provoke maximum fear

Medicine in mass casualty incidents

- Conventional medicine - do the greatest good for the individual patient
- Disaster medicine - do the greatest good for the greatest number of patients ==>
  - triage of victims
  - economizing resources
  - reliance on available assets
  - mass evacuation

Possible mass casualty scenarios

- Pandemic infections (febrile respiratory illnesses)
- Bioterrorism
- Chemical injuries
- Radiation injuries
- Natural disasters
- Explosions

Febrile Respiratory Illnesses (FRI) & Bioterrorism

Infections capable of mass casualties

- Naturally-occurring
  - COVID 19
  - influenza; e.g., swine influenza A (H1N1)
  - severe acute respiratory syndrome (SARS) - coronavirus infection
  - avian (bird) flu

Infections capable mass casualties

- bioterrorist threats
  - pulmonary anthrax
  - smallpox
  - plague
  - tularemia
  - viral hemorrhagic fever; e.g., Ebola, Marburg

Influenza

- Causative agent - viruses
- Communication routes
  - airborne
  - contact
- Manifestations
  - fever
  - headache
  - muscle pain
  - malaise
  - pneumonia - may progress to RDS

Influenza

- Diagnosis
  - index of suspicion - clinical signs, multiple cases
  - oral swab for viral ID
  - clinical signs for mass victims
- Problem - many people may be exposed before diagnosis is made
  - masks for patients in ER waiting rooms??

Influenza

- Management
  - home care, if possible & safe
  - supportive care; e.g., hydration
  - oxygen
  - ventilation with low TV
  - antiviral agents
    - remdesivir- COVID19
    - amantidines
    - neuramidinase inhibitors

Influenza

- Prevention
  - social distancing
  - hand washing, hand sanitizers
  - vaccination
  - antiviral agents
    - amantidine
    - neuramidinase inhibitors
  - airborne isolation of patients

Influenza

- Prevention
  - social distancing
  - hand washing, hand sanitizers
  - vaccination
  - antiviral agents
    - amantidines
    - neuramidinase inhibitors
  - airborne isolation of patients
  - personal protection equipment (PPE)
    - N95 mask
    - respirator for high-risk procedures
  - minimize high-risk procedures

Pulmonary anthrax

- Pulmonary form likely due to bioterrorism
- Causative agent - bacillus anthracis
  - spore forming
  - gram positive rod
- Communication route
  - inhalation of spores
  - no person-to-person transfer

Pulmonary anthrax

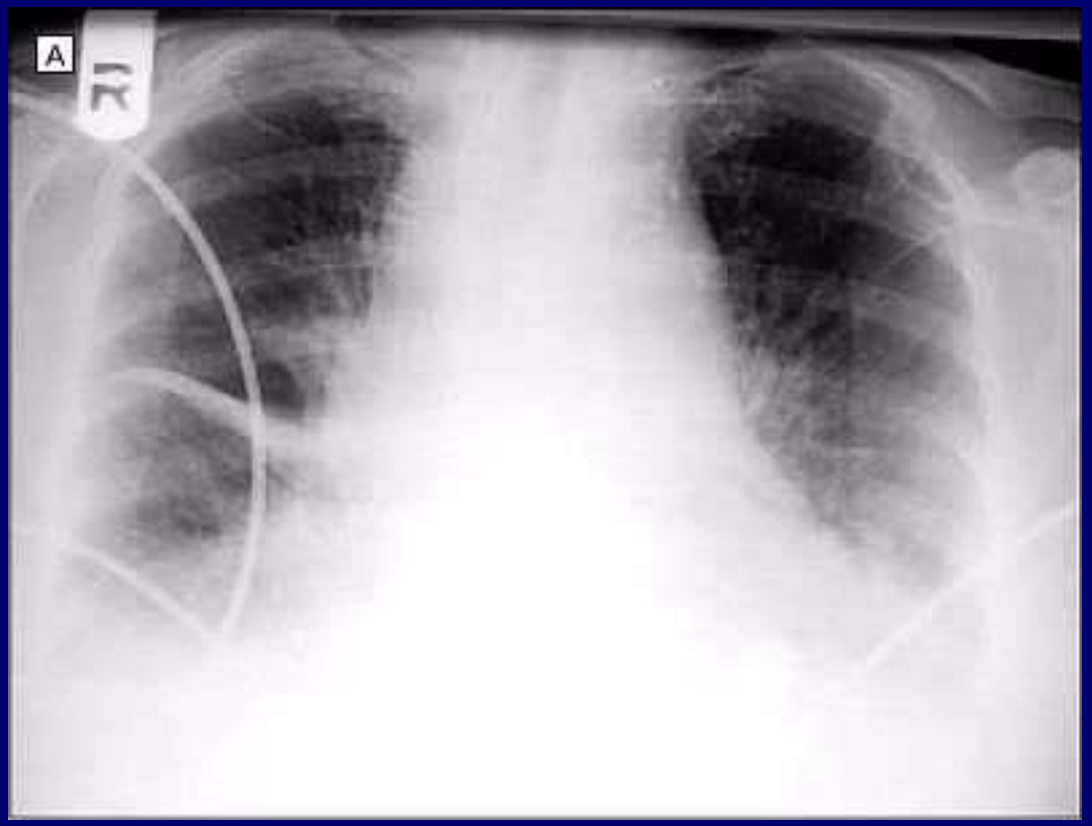
- Manifestations
  - 3-5 day incubation period
  - fever, chills
  - dyspnea, chest pain
  - cough
  - headache
  - nausea & vomiting
  - hypoxemia
  - stridor
  - widened mediastinum on radiograph

Pulmonary anthrax

- Diagnosis
  - index of suspicion- exposure risk
    - occupation
    - location
  - pathognomonic (distinct signature)
    - previously healthy adult
    - overwhelming flu-like signs
    - widened mediastinum on CXR

Pulmonary anthrax

- widened mediastinum on XCR



Pulmonary anthrax

- Diagnosis
  - sputum exams are NOT useful
  - standard blood culture- growth in 6-24 H

Pulmonary anthrax

- Management
  - supportive - ventilation, O2
  - antibiotics
    - doxycycline
    - ciproflaxin
    - amoxicillin

Pulmonary anthrax

- Prevention
  - universal precautions for patient care- no special barriers
  - antibiotics for suspected exposure (60 D)
  - human live attenuated vaccine
    - three injections, two weeks apart
    - three injections at 6, 12, 18 mo.

Smallpox

- Causative agents
  - variola minor virus (less virulent)
  - variola major virus
- Communication route
  - inhaled droplets, aerosols
  - very contagious

Smallpox

- Manifestations
  - incubation - 10-14 days
  - pre-eruptive phase (lasts 2-4D)
    - ƒhigh fever
    - ƒsevere headache
    - ƒmalaise
  - eruptive phase
    - ƒcentrifugal rash, starting on face
    - ƒevolves to pustular rash

Smallpox Rash

Smallpox

- Manifestations
  - toxemia
  - encephalitis
  - mortality (20-30%)- 5th or 6th day after onset of rash

Smallpox

- Diagnosis - one suspected case represents an international health emergency
  - Characteristic rash
    - centrifugal distribution
    - same stage of development at each location
    - palmar and plantar location (rare with chickenpox)
    - confirmed by laboratory analysis

Smallpox

- Management
  - strict isolation for hospitalized patients
  - home care recommended
  - supportive care
  - antibiotics for secondary bacterial infection
  - antiviral agents
    - currently, none are approved
    - agents for HIV have potential

Smallpox

- Prevention - post-exposure control
  - all face-to-face contacts with victim
    - vaccinated
    - surveillance for fever, rash
  - vaccination of healthcare workers, police, transit workers, etc.

Smallpox

- Prevention - hospital infection control
  - rooms- negative pressure with HEPA
  - vaccination of employees, patients
  - laundry and waste- biohazards

Plague

- Causative agent
  - yersinia pestis
  - gram negative rod
- Communication route(s)
  - bite from infected flea
  - droplets, aerosol (bioterrorism)
  - contact (person-to-person)

Plague

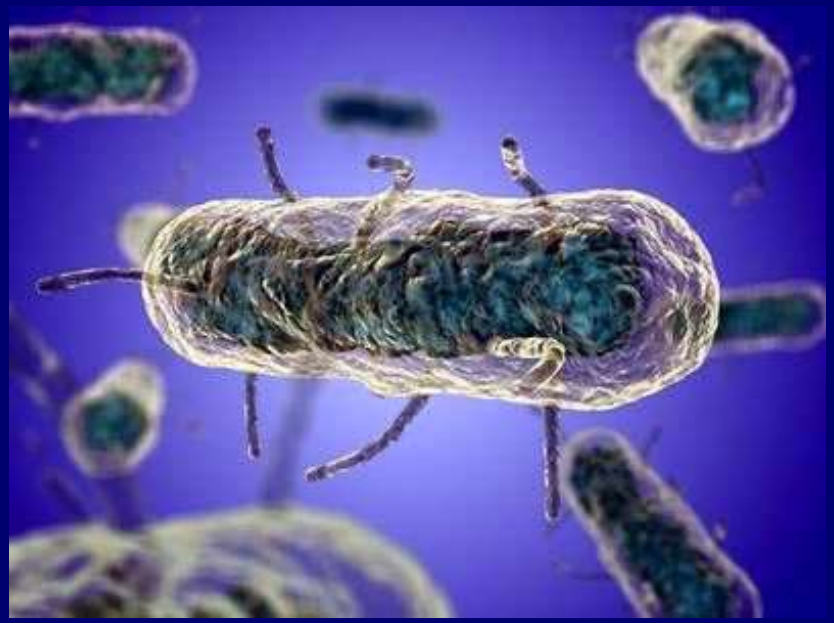
- Forms
  - bubonic (flea bites)
  - septicemic
  - pneumonic (bioterrorist aerosols)

Plague (pneumonic)

- Manifestations (pneumonic)
  - incubation - hours to days
  - malaise
  - high fever, chills
  - hemoptysis
  - leukocytemia
  - rapidly progressive pneumonia
  - hypoxemia
  - mortality- 100% if untreated

Plague (pneumonic)

- Diagnosis
  - index of suspicion- sudden outbreak of severe pneumonia & sepsis
  - Gram stain- sputum or blood, gram negative bipolar rod



Plague (pneumonic)

- Management
  - supportive - ventilation, oxygen
  - antibiotics- initiate STAT
    - ƒstreptomycin- drug of choice
    - ƒgentamycin
    - ƒdoxycycline

Plague (pneumonic)

- Prevention
  - Post-exposure antibiotics- seven days post-exposure
    - doxycycline
    - tetracycline
    - TMP-SMT (Bactrim™)

Plague (pneumonic)

- Respiratory isolation
  - patient for first 48 hours
  - close contacts who refuse chemoprophylaxis
- Vaccine- no longer available
- Decontamination- usual measures

Tularemia

- Causative agent
  - francisella tularensis
  - gram negative bacterium
  - zoonotic organism (rabbit fever)
- Communication route(s)
  - contact with infected animals
  - vectors; e.g., ticks, flies
  - inhalation (bioterrorism)
  - no person-to-person transfer

Tularemia

- Common carrier

Tularemia

- Manifestations (ulceroglandular form)
  - cutaneous ulcer
  - lymph gland enlargement
  - fever, chills
  - headache, malaise
  - may progress to pneumonia

Tularemia

- Manifestations (ulceroglandular form)
  - cutaneous ulcer
  - rabbit bite

Tularemia

- Manifestations (bioterrorist forms)
  - incubation - 2-10 days
  - typhoidal form
    - ƒfever,
    - ƒcough,
    - ƒchest pain
    - ƒshortness of breath
    - ƒmortality - 35%

Tularemia

- Manifestations (bioterrorist forms)
  - pneumonic form - severe atypical pneumonia
    - ƒARDS ==> respiratory failure
    - ƒmortality unknown - no opportunity for study

Tularemia

- Diagnosis
  - may be missed on sputum exam
  - histology - intracellular organisms
  - serology
- Management
  - support - ventilation, oxygen
  - antibiotics
    - streptomycin - drug of choice
    - gentamycin, amikacin
    - chloramphenicol (meningitis)

Tularemia

- Prevention
  - antibiotics for suspected exposure
  - universal precautions for victims

Viral hemorrhagic fevers

- Causative agents
  - Marburg virus (Angola, 2005)
  - Ebola virus (4 species)
- Communication routes
  - contact with non-human primates
  - droplet particles
    - infected persons
    - bioterrorism

Viral hemorrhagic fevers

- Manifestations
  - incubation period - 4-5 D
  - fever, chills, headache
  - nausea, vomiting, diarrhea, abdominal pain

Viral hemorrhagic fevers

- Manifestations (cont'd)
  - prostration, stupor, shock
  - bleeding: conjunctival, soft tissue, skin (rash), gastrointestinal, alveolar
  - mortality
    - Marburg.....about 25%
    - Ebola.....50-90% (depends on strain)

Viral hemorrhagic fevers

- Diagnosis
  - history of exposure
  - clinical findings
- Management
  - strict isolation
  - supportive
    - ƒshock
    - ƒventilatory failure (ARDS is likely)

Viral hemorrhagic fevers

- Prevention
  - strict isolation of victims, exposures
  - personal protective equipment, including airborne precautions

High-risk procedures

- endotracheal intubation
- noninvasive positive pressure ventilation
- bag-mask ventilation
- bronchoscopy

High-risk procedures

- exhaled aerosols - all nebulizers
- mask without expiratory filter

Flow of patient care

- Patient presents with FRI ==>
  - Placed in droplet or airborne isolation
  - Caregivers use personal protective equipment (PPE)
  - Diagnosis initiated

Flow of patient care

- If the etiology is NOT an emergency critical care agent ==>
  - isolation removed or maintained, as indicated
  - PPE for high-risk procedures
  - specific treatment undertaken

Flow of patient care

- If the etiology is an emergency critical care agent ==>
  - public health agencies notified
  - isolation maintained, as indicated
  - PPE for all high-risk procedures

Flow of patient care

- Presence of cases associated with ARDS ==>
  - Low TV ventilation
  - surge capacity plan activated with ventilator stockpile
  - aggressive PPE for caregivers
  - vaccination or antiviral therapy for caregivers

Personal protective equipment

- Level A - self-contained breathing apparatus and encapsulating chemical-protective (TECP) suit.
- Level B - self-contained breathing apparatus or supplied-air respirator and nonencapsulated chemical-resistant garments, gloves, and boots

Personal protection

- Level C - air-purifying respirator and non-encapsulated chemical-resistant clothing, gloves and boots.
- Level D - universal precautions

Environmental controls

- Mass infection with airborne agent will overwhelm conventional isolation capabilities
- Options:
  - cohorting patients
  - industrial exhaust fans
  - high-capacity portable HEPA units
- Masks for infected patients

Summary & Review

- Types of disasters
- Medicine in mass casualty events
- Febrile respiratory illnesses
  - Pandemic influenza
  - Pulmonary anthrax
  - Smallpox
  - Plague
  - Tularemia
  - Viral hemorrhagic fever

Summary & Review

- High risk procedures
- Optimal flow of patient care
- Personal protective equipment
- Environmental controls

Chemical Injuries

Categories of chemical agents

- Lung damaging agents
- Blood agents
- Blistering agents
- Nerve agents

Categories of chemical agents

- Initial management for all agents
  - rescuer personal protection
  - removal of victim from source
  - life support interventions
  - decontamination

Lung damaging agents

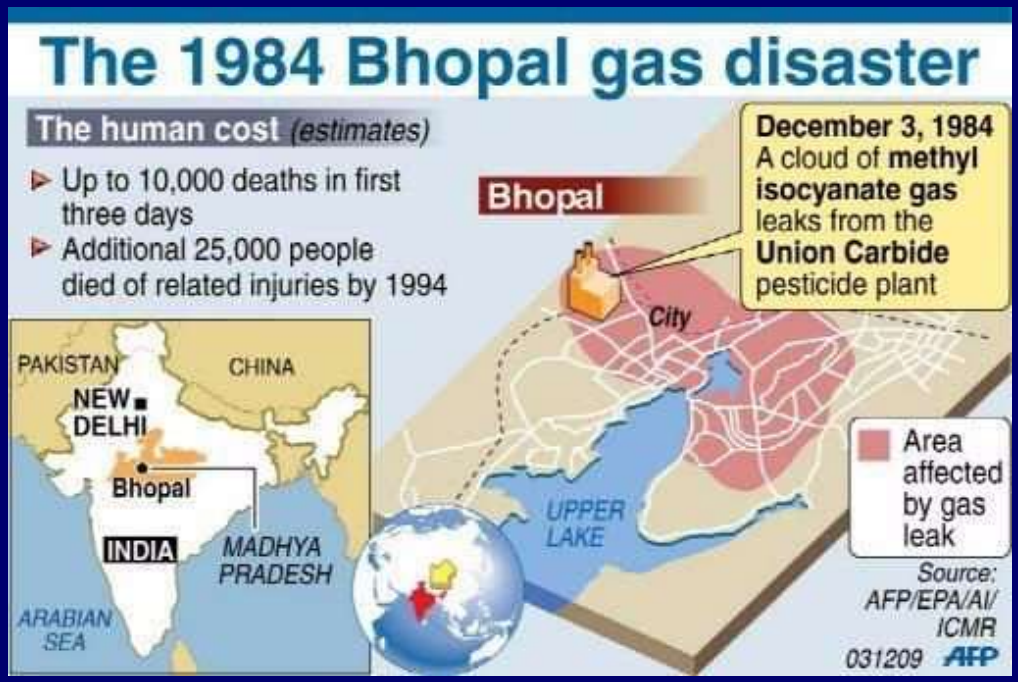
- Types of events
  - chemical warfare
  - terrorism
  - industrial accidents - most likely scenario

Lung damaging agents

- Types of events- industrial accidents

Terre Haute, IN
2015 (acid spill)

Lung damaging agents



Lung damaging agents

- Agents
  - chlorine - manufacture of paper, textiles
  - ammonia - manufacture of fertilizer
  - methyl isocyanate (MIC) - manufacture of pesticides; e.g., Sevin (Bhopal)
  - phosgene
    - WW I chemical warfare
    - manufacturing - pesticides, dyes, pharmaceuticals

Lung damaging agents

- Effects
  - copious secretions
  - cough
  - stridor
  - laryngeal obstruction
  - bronchospasm
  - noncardiogenic pulmonary edema (ARDS)
  - severe ocular burning (methyl isocyanate)

Lung damaging agents

- Treatment
  - intubation, ventilation for severe exposure
  - humidified air or O2 (mild exposure)
  - bronchodilators
  - inhaled $NaHCO_3$ for chlorine
  - removal of contact lenses

Blood agents

- Agents
  - hydrogen cyanide
  - cyanogen chloride
- Sources
  - manufacturing
  - mining
  - metalworking
  - byproduct of combustion - fires
  - chemical warfare

Blood agents

- Pathophysiology - block cytochrome, inhibiting cellular O2 uptake (histotoxic hypoxia)
- Effects
  - bitter almond smell reported by victim
  - bright red venous blood
  - tachypnea
  - metabolic acidemia

Blood agents

- Treatment
  - antidotes to displace and excrete cyanide
    - famyl nitrite
    - sodium nitrite
    - sodium thiosulfate
  - oxygen
  - hyperventilation
  - $NaHCO_3$

Blister agents

- Agents
  - mustard
  - lewisite
  - phosgene oxime
- Sources
  - chemical warfare
  - hot dog overdose (mustard)

Blister agents

- Effects (mustard has delayed effects)
  - skin blisters
  - burning eyes
  - injury to all airways
    - upper airway obstruction
    - peripheral airway obstruction
  - pulmonary edema
  - gastrointestinal damage - vomiting, diarrhea

Blister agents

- Effects
  - skin blisters
  - burning eyes
  - injury to all airways

Blister agents

- Treatment
  - there are no antidotes
  - supportive
    - oxygen, intubation, ventilation
    - bronchodilators
    - medications for vomiting, diarrhea

Nerve agents

- Agents - organophosphates
  - GA (Tabun) - genocide
  - GB (Sarin) - genocide (Japan, 1994)
  - GD (Soman) - genocide
  - GF
  - VX
  - kids
  - significant other
  - bosses
  - employees

Nerve agents

- Agents - organophosphates
  - Pesticides; e.g,:
    - Sevin
    - diazinon
    - malathione

Nerve agents

- Action - inhibit cholinesterase, which causes accumulation of acetylcholine at nerve synapses
- skeletal muscle (nicotinic) effects
  - twitching
  - weakness
  - paralysis, including diaphragm
- muscarinic effects - cholinergic crisis

Nerve agents

- Cholinergic crisis (see neuro lesson)
  - Salivation
  - Lacrimation
  - Urination
  - Diaphoresis
  - GI distress (diarrhea, vomiting)
  - Emesis
  - Bronchospasm

Nerve agents

- Treatment
  - rescuer and caregiver personal protection - caregivers in Japan sickened from Sarin
  - decontamination of victims
    - water
    - calcium hypochlorite
    - charcoal & absorptive resins (military)

Nerve agents

- Treatment - antidotes
  - atropine - blocks nicotinic and muscarinic effects of acetylcholine (massive dosages)
  - pralidoxime (2-PAM-Cl) - removes organophosphoryl molecule

Nerve agents

- Supportive treatment
  - endotracheal intubation
  - ventilation
  - bronchodilators - albuterol & ipratropium
  - tracheal suctioning
  - benzodiazipine for seizures

Chemical agents

- Additional causes of surge of patients to institution will include frightened people who think they were exposed - it will be hard to sort them out

Summary & Review

- Chemical injuries are likely due to industrial accidents
- Lung damaging agents; e.g., chlorine
- Blood agents; e.g., cyanide
- Blistering agents; e.g., mustard
- Nerve agents; e.g., Sarin

Radiation Injuries

Radiation injuries

- Causes (mass casualties)
  - accidents; e.g., nuclear reactor meltdown
    - Three Mile Island (Pa.)??
    - Chernobyl (Ukraine, 1986)
  - nuclear warfare

Radiation injuries

- Causes
  - terrorism
    - radiation dispersion device, AKA "dirty bomb"
    - non-explosive radiation dispersal; e.g, radioactive material left in public place

Injuries with nuclear explosion

- Blast injuries - multiple types of trauma
- Thermal injuries
  - flash burns
  - flame burns
- Ionizing radiation injury

Ionizing radiation types

- alpha particles - stopped by sheet of paper
- beta particles - stopped by clothing
- gamma rays - stopped by inches of concrete or inch of lead
- xrays - concrete or inch of lead
- neutrons - concrete or inch of lead
- cell phones - nothing stops their annoying effects

Ionizing radiation exposure

- External radiation - exposure to source
- Contamination
  - external (skin, hair) - exposure to radioactive debris (fallout), which can be transmitted to rescuers and caregivers

Ionizing radiation exposure

- External radiation - exposure to source
- Contamination
  - external (skin, hair) - exposure to radioactive debris (fallout), which can be shared with caregivers
  - internal - entry of fallout via:
    - inhalation
    - ingestion
    - open wounds ==> decreased survival

Radiation injuries

- Severe radiation ==> cell death
- Less severe radiation ==> cell injury
  - repaired ==> scarring
  - altered genetic information ==>
    - ƒcarcinoma
    - ƒteratogenesis (birth defects)

Radiation injuries

- Teratogenesis

Radiation injuries

- Severity of injury depends on dose received, which is function of:
  - exposure time
  - radiation dosage

Radiation sickness

- high dose manifestations:
  - nausea
  - vomiting
  - diarrhea
  - fatigue
  - mental status changes
  - fever
  - respiratory distress

Radiation sickness

- delayed manifestations:
  - decreased WBC, platelet production
  - severe gastrointestinal damage
  - severe CNS damage
  - teratogenesis - birth defects
  - carcinoma

Treatment

- wound closure
- medical treatment may not be indicated for first few hours
- supportive treatment
- potassium iodide (SSKI) - protects only the thyroid from radioactive iodine

Summary & Review

- Causes of mass casualty radiation injuries; e.g., meltdowns, terrorism
- Nuclear explosion injury types; e.g., radiation injury
- Radiation exposures: external; contamination
- Manifestations of radiation sickness
- Radiation sickness treatment

Explosions
Blast Injuries

Sources of blast injuries

- Industrial accidents
- Natural disasters; e.g., earthquakes and natural gas lines
- Warfare
- Terrorism - blast injuries are the most common result; e.g.:
  - Mumbai, India, 2006
  - London, 2005
  - New York City, 2001
  - Oklahoma City, 1995

Oklahoma City, Murrah Building, 1995

Categories of blast injuries

- Primary blast injuries
- Secondary blast injuries
- Tertiary blast injuries
- Quaternary blast injuries

Primary blast injuries

- Caused by high-energy explosions that produce a pressure wave
- Pressure wave can cause severe damage without overt signs of trauma
- Pressure wave primarily affects gas-filled structures:
  - abdominal hemorrhage, perforation
  - cerebral concussion
  - blast lung - bilateral lung contusion
  - tympanic membrane - red flag

Secondary blast injuries

- Caused by flying debris
- Penetrating and blunt force

injuries to any body parts; e.g., open pneumothorax

Tertiary blast injuries

- Caused by victims being propelled by wind from explosion
- Most common injuries:
  - fractures and traumatic amputations
  - brain injury - open and closed

Quaternary blast injuries

- Injuries not caused by the explosion:
  - burns
  - crush injuries from structure collapse
  - exacerbations of asthma & COPD from inhalation of dust
  - angina, MI

Respiratory care

- Supplemental O2
- Airway management - difficult airways are likely
- Ventilation for:
  - pulmonary contusions
  - bronchopulmonary fistulae
  - massive trauma - acute lung injury
  - brain and spinal cord injuries

Summary & Review

- Sources of blast injuries - accidents, natural disasters, terrorism
- Categories of injuries
  - primary
  - secondary
  - tertiary
  - quaternary
- Management
  - airway management
  - ventilation

Natural Disasters

Types of natural disasters

- Floods - most common
- Hurricanes - wind, flooding, fires
- Tornadoes - wind
- Wild fires
- Avalanches/landslides/mudslides

Types of natural disasters

- Heat waves
- Blizzards/extreme cold
- Earthquakes - collapses, explosions
- Tsunamis
- Volcanic eruptions

Injuries from natural disasters

- Near drowning - flooding
- Suffocation - structural collapse
- Crush injuries - structural collapse
- Blunt trauma - structural collapse, winds
- Penetrating trauma - structural collapse, winds
- Thermal injuries - wildfires, blizzards
- Inhalation injuries - fires, collapses
- Psychological trauma - all disasters

Additional problems

- Services lost, impaired and/or overwhelmed; e.g.:
  - water
  - electricity
  - sewer
  - communications
  - fire, EMS, police agencies

Additional problems

- Transportation problems
  - impassable roads
  - loss of vehicles
  - death, injury or illness of transport personnel
- Destruction of healthcare facilities
- Impaired sanitation - increased risk for infectious diseases
- Criminal activities; e.g., looting

Mass Casualty
Critical Care Demands

Surge capacity

- Definition - Health Care system's ability to expand quickly to meet an increased demand for medical care in the event of a large scale public health emergency (AHRQ definition)
- The same event can produce different stresses on different institutions; e.g., influx of trauma patients to non-trauma ER

Surge considerations

- Critical care capabilities are essential to limiting mortality in a mass casualty event
- Facilities may not be able to divert or evacuate casualties
- Assistance from other agencies will take time

Components of surge capacity

- System
- Space
- Staff
- Stuff

System

- Command - incident command system (ICS) for overall management
- Control - control of facility infrastructure; e.g., building access
- Communication - internal and external communications
- Coordination - coordination of facility response with other facilities and public agencies

Space considerations

- Critical care beds are premium
- Facility must identify and plan for using alternate spaces to accommodate surge patients
- Facility should train personnel for alternate space utilization

Facility space categories

- Conventional space - available for daily operations
- Contingency space - areas in facility that can be used temporarily for patient services
- Crisis space - do not meet usual standards of care; but, sufficient for disaster situation

Space response

- Conventional space
  - economize on critical care beds, moving patients to step-down units, general care floors
  - cancel elective procedures
  - discharge patients, as possible
  - add beds to patient rooms - eliminate private rooms

Space response

- Contingency spaces that can be used for patient care
  - recovery rooms
  - surgical waiting areas
  - procedural areas; e.g, dialysis units

Space response

- Crisis spaces that can be equipped for patient care:
  - hallways
  - lobbies
  - adjacent medical offices
  - temporary structures; e.g., tents

Staff considerations

- Personnel may be unable to travel to facility, because of roads, etc.
- Personnel may be unwilling to report, due to:
  - illness or injury from event (victims)
  - fear of contracting illness
  - concerns over care for family, pets
- Critical care personnel need to be enabled to focus on their primary patient care responsibilities

Staff considerations

- Facility must have plan to mobilize its personnel in response to emergency
- Facility must have plan to use ad hoc staff effectively
- Facility must have mechanism for emergency credentials and privileges for ad hoc staff

Staffing categories

- Conventional - staff within the facility who are credentialed and privileged at facility
- Contingency - staff within the facility who can assume additional duties or staff imported from other facilities
- Crisis - non-clinical staff assigned to basic patient care

Staffing response

- Conventional
  - departmental managers assume patient care (Uh-oh!!)
  - surgeons assess, treat ER trauma patients

Staffing response

- Contingency
  - staff within the facility assume additional duties, under supervision
  - staff imported from other facilities
  - provider extenders; e.g., Project XTREME to cross train:
    - physicians, physician assistants
    - nurses
    - physical therapists

Staffing response

- Crisis - staff likely to perform beyond their usual scope of practice
  - non-critical care physicians assisting in critical care areas
  - lay personnel assisting with patient hygiene and monitoring
  - housekeeping providing bag-valve ventilation

Stuff considerations

- Hospitals and suppliers avoid surplus of materials
- Medications and supplies stockpiled by CDC for delivery
- Strategic national stockpile (SNS)
- Transportation of supplies to facility may be crippled

Stuff considerations

- Mass casualties will overwhelm critical care equipment and supplies on-hand; e.g.:
  - mechanical ventilators
  - mechanical ventilation supplies
  - oxygen
  - oxygen administration supplies
  - monitors; e.g., pulse oximeters

Options for short-supply situation

- Prepare (stockpile) before the event
- Substitute equivalent items
- Adapt, using items that are sufficient, though not ideal
- Conserve resources; e.g., oxygen
- Reuse items after disinfection
- Reallocate items or therapy to patient with greater benefit

Stuff

- Conventional supply - maximum supplies for usual facility operations
  - critical care equipment and supplies should NEVER be in short-supply
  - example: minimal inventory of ventilator circuits ==> trouble!!
  - the inventory should ALWAYS include an excess of personal protective equipment

Stuff

- Contingency supply- conventional inventory exhausted; response examples:
  - adapt - pulse oximeters to monitor heart rate
  - substitute - transport or anesthesia ventilators for ICU ventilators
  - reuse - manual resuscitators

Stuff

- Crisis supply - overwhelming number of critical care patients
  - bag-valve ventilation
  - accept lower limits; e.g., SpO2 to conserve oxygen
  - reallocate therapeutics ==> ethical decisions

Respiratory Care Stuff

Oxygen

- Potential sources
  - bulk liquid oxygen system
  - cylinders
  - oxygen concentrators
  - mobile liquid oxygen systems

Bulk liquid oxygen system

- Failure possibilities
  - structural damage - container, pipe system
  - impaired delivery of oxygen; e.g.; roads, lack of personnel or vehicles
  - damage to gas separation plants
  - overwhelming demand for oxygen

Oxygen cylinders

- Mass casualty applications
  - small cylinders
    - ƒtransports
    - ƒtemporary therapy
    - ƒbuilt-in regulator most desirable
  - large cylinders
    - ƒindividual long-term therapy
    - ƒback-pressure feed units
    - ƒmanifolds can create multiple-patient capabilities

Oxygen cylinders

- Emergency oxygen manifolds

Western MD8
Octi-flo

WT Farley
emergency oxygen
supply

Oxygen cylinders

- Limitations
  - facility storage capacity
  - transport difficulties
- Infectious events demand disinfection of cylinders before transport.

Oxygen concentrators

- Mass casualty applications - large oxygen generators
  - refill cylinders
  - back pressure feed units for capability of 93% O2 at 50 PSIG

Oxygen concentrators

- Mass casualty applications - large oxygen generators
  - refill cylinders
  - back pressure feed units for capability of 93% O2 at 50 PSIG
- Limitations
  - size - storage space
  - require electricity
  - expense

Oxygen concentrators

- Mass casualty applications - large oxygen generators

Pioneer Oxygen Generator

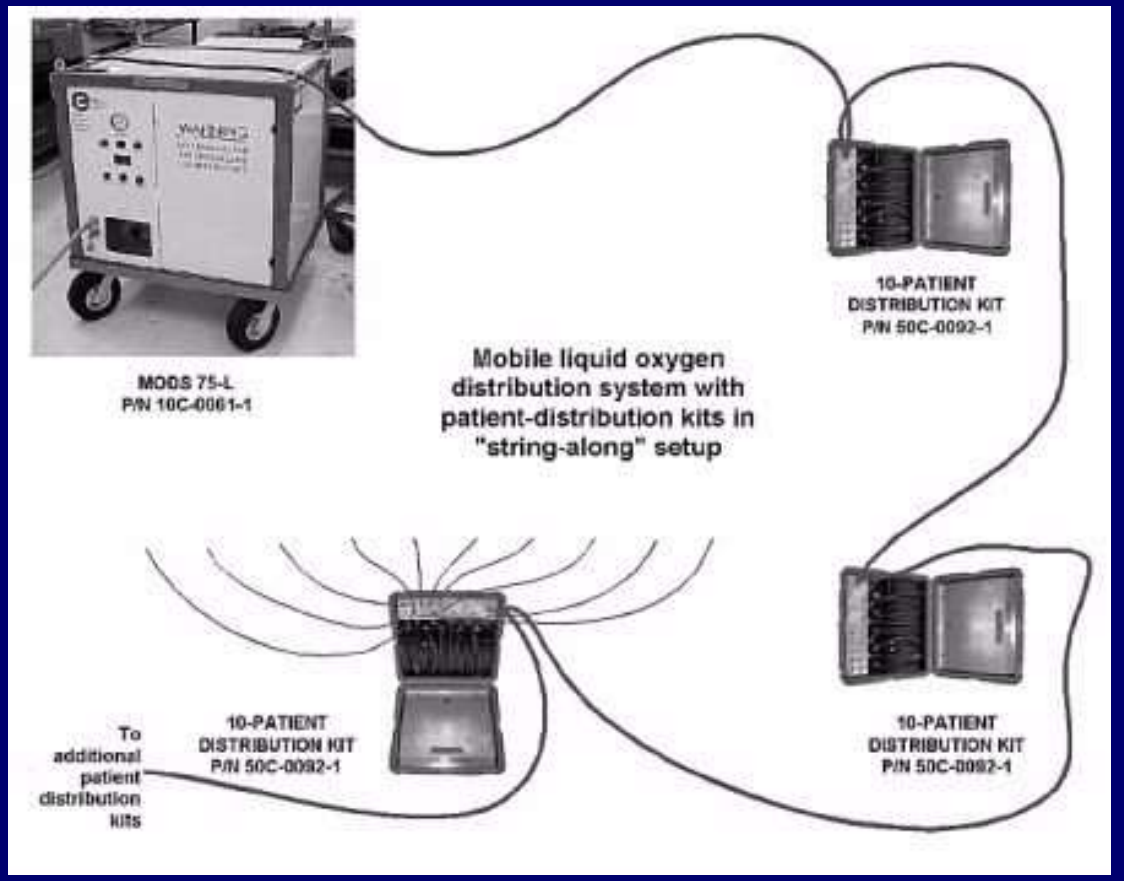
Mobile liquid oxygen systems

- Primarily used to refill aircraft oxygen systems
- Requires less space than cylinders
- Mass casualty application - refill mobile multiple-patient system

Mobile liquid oxygen systems

- Multiple-patient system

Hartwell Surevent



MODS 75-L

Oxygen conservation methods

- repair all leaking outlets - this should be an ongoing effort
- turn flowmeters off when not in use
- use minimum FIO2 and liter flows necessary
- use reservoir cannulae
- use gas-sparing ventilators
- use HME's for humidification
- target lower SpO2

Endotracheal intubation

- Caregivers are at risk for contagions and some chemical injuries
- Emergency intubations should be avoided
- Preparation for intubation is essential
- Patient must be sedated
- Performed in negative-pressure room
- All caregivers wear PPE

Ventilator sources

- Conventional
  - on-hand intensive care ventilators
  - rental ventilators - availability?
- Contingency situation
  - transport ventilators
  - borrowed - availability?
  - NPPV devices - NOT for mass casualties
  - anesthesia ventilators
  - negative pressure ventilators - no intubation required

Ventilator sources

- Crisis situation
  - pressure-cycled ventilators??
  - single patient use ventilators??
  - bag-valve ventilators
  - National stockpile ventilator kits
    - Impact Eagle 754
    - Puritan-Bennett LP-10 (discontinued)

Mass casualty ventilator requirements

- Approved for adult and pediatric patients
- Capability to operate without 50 PSIG source
- Battery life $\geq$ 4 hours
- Constant volume delivery
- CMV mode included
- Adjustable PEEP capability (5-15 cm H2O

Mass casualty ventilator requirements

- Separate controls for rate and TV
- Monitors for airway pressure and TV
- Alarms:
  - circuit disconnect
  - high & low airway pressure
  - loss of electrical power
  - loss of high pressure gas source
- Ease of use

Ventilators

- Intensive care ventilators
- Noninvasive positive pressure ventilators
- Transport ventilators
- Anesthesia ventilators
- Negative pressure cuirass ventilators
- Pressure-cycled, single use
- Bag-valve ventilators
- National stockpile ventilator kits

Ventilators

- Intensive care ventilators
  - may be too expensive to stock for surge requirements
  - requires respiratory therapist to manage
  - reserve for sickest patients; e.g., ARDS
  - cradle-to-grave devices also may be applied to neonates and small infants

Ventilators

- Noninvasive positive pressure ventilators
  - unsuitable for contagious conditions
  - unsuitable for ARDS
  - requires inordinate staff time

Ventilators

- Transport ventilators
  - some have ICU ventilator capabilities
  - less expensive than ICU ventilators
  - some are oxygen & electrical power economical
  - likely choice as ventilator to stock for surge

Ventilators

- Anesthesia ventilators
  - some will be needed for emergency surgical procedures
  - managed by:
    - anesthesia personnel - availability of time?
    - respiratory therapists - require orientation to devices

Ventilators

- Negative pressure cuirass ventilators
  - no intubation required - less risk of infection for caregivers
  - some casualties require airways
  - United Hayek MRTX™ was tested as an option for application to patients by physicians at the scene- FDA approved in 2008

Ventilators

- Pressure-cycled, single-use ventilators
  - non-constant volume delivery
  - no alarms
  - not for unattended patients
  - require 50 PSIG source
  - use large amounts of gas

Ventilators

- Bag-valve ventilators
  - short-term support
  - effective ventilation without electrical power
  - ventilation can be provided by ancillary staff, volunteers

Ventilators

- National stockpile ventilator kits
  - kit includes ventilators,ventilator supplies, instructional media
  - airway management materials contained in 12 hour push packages
  - takes hours, to days for delivery

Organizational preparation

- Maintain stocks of devices and supplies
- Plan for mass casualty events
- Rehearse mass casualty scenarios
- Prepare and train ALL personnel for mass casualty events

Individual preparation

- Gain and maintain familiarity with hospital mass casualty plan
- Familiarize with likely surge equipment and supplies; e.g.,
  - SNS ventilators
  - others acquired for mass casualty events
- Participate in planning, rehearsals and debriefings

Individual preparation

- Personal preparations
  - plan for disposition of family, pets, etc.
  - assemble and store personal kit
    - clothes, underwear
    - toiletries
    - medications
    - eyeglasses, contact lenses

Summary & Review

- Surge capacity components
  - system
  - space
  - staff
  - stuff
- Conventional, contingency, crisis modes

Summary & Review

- Respiratory care stuff
  - oxygen resources
  - ventilator resources
- Organizational preparations
- Individual preparation

END

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