### Learning Objectives:
- Identify infections capable of causing mass casualties and describe their etiologies, manifestations, diagnosis, management, and prevention.
- Describe 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.
- 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.

### 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
    - 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
  - 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 ARDS
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??

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

**Prevention**
- vaccination
- antiviral agents
  - amantidines
  - neuraminidase inhibitors
- airborne isolation of patients
- personal protection equipment (PPE)
  - N95 mask
  - respirator for high-risk procedures
- minimize high-risk procedures

FYI - Click for video with advice for flu management & prevention
http://www.youtube.com/watch?v=zJ6VT7ciR1o

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

**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

Click to see chest radiograph of pulmonary anthrax: [http://www.ph.ucla.edu/epi/bioter/minafig1a.jpg](http://www.ph.ucla.edu/epi/bioter/minafig1a.jpg)

**Management**
- Supportive - ventilation, O2
- Antibiotics
  - Doxycycline
  - Ciprofloxin
  - Amoxicillin

**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.

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**Smallpox**

**Causative agents**
- Variola minor virus (less virulent)
- Variola major virus

**Communication route**
- Inhaled droplets, aerosols
- Very contagious

**Manifestations**
- Incubation - 10-14 days
- Pre-eruptive phase (lasts 2-4D)
  - High fever
  - Severe headache
  - Malaise
- Eruptive phase
  - Centrifugal rash, starting on face
  - Evolves 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
  - pneumatic (bioterrorist aerosols)

Plague (pneumonic)

- **Manifestations (pneumonic)**
  - incubation - hours to days
  - malaise
  - high fever, chills
  - hemoptysis
  - leukocytosis
  - 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

FYI - click to see *yersinia pestis*
http://webs.wichita.edu/mschneegurt/biol103/lecture14/pestis_big.jpg

Plague (pneumonic)

- **Management**
  - supportive - ventilation, oxygen
  - antibiotics- initiate STAT
    - streptomycin- drug of choice
    - gentamycin
    - doxycycline

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

Tularemia
- Manifestations (bioterrorist forms)
  ◆ incubation - 2-10 days
  ◆ typhoidal form
    - fever,
    - cough,
    - chest pain
    - shortness of breath
    - mortality - 35%

Tularemia
- Manifestations (bioterrorist forms)
  ◆ pneumonic form - severe atypical pneumonia
    - ARDS ==> respiratory failure
    - mortality 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

FYI - Click to see trailer of "Outbreak" movie
http://www.youtube.com/watch?v=Mj9SUJdpJS4

Viral hemorrhagic fevers

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

FYI - Click to download article on viral hemorrhagic fevers

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
    - shock
    - ventilatory failure (ARDS is likely)

- 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
- nonrebreathing mask without expiratory filter

Click to see video that shows exhaled aerosols (Video courtesy of Cliff Ansel, President, Thornhill Research, Toronto)

**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.

Click to see level A PPE

Personal protection

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

Click for personal protective equipment requirements.
You will need to scroll down the page.
http://www.ehso.com/OSHA_PPE_EPA_Levels.htm
Click to see level E personal protective equipment

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

Click to see Iso-O2 & Hi-Ox80 masks. At website, click 'projects, then mask names
http://www.thornhillresearch.com/

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

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

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**Lung damaging agents**

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

FYI - click for information on Montana chlorine spill
http://www.toxictrains.org/Derailments/Alberton%20Montana.htm
FYI - click for video on SC chlorine spill (3 min)
http://www.youtube.com/watch?v=OoDouOrQPAs
FYI - click for video on Bhopal disaster (11 min.)
http://www.youtube.com/watch?v=Zx-BfXlJ09c&feature=channel

**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

**Effects**

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

**Treatment**

- intubation, ventilation for severe exposure
- humidified air or O2 (mild exposure)
- bronchodilators
- inhaled NaHCO3 for chlorine
- removal of contact lenses
**Blood agents**

### Agents
- hydrogen cyanide
- cyanogen chloride

### Sources
- manufacturing
- mining
- metalworking
- byproduct of combustion - fires
- chemical warfare

### Pathophysiology
- block cytochrome, inhibiting cellular O2 uptake (histotoxic hypoxia)

### Effects
- bitter almond smell reported by victim
- bright red venous blood
- tachypnea
- metabolic acidemia

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**Blood agents**

### Treatment
- antidotes to displace and excrete cyanide
  - amyl nitrite
  - sodium nitrite
  - sodium thiosulfate
- oxygen
- hyperventilation
- NaHCO3

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**Blister agents**

### Agents
- mustard
- lewisite
- phosgene oxime

### Sources
- chemical warfare
- hot dog overdose (mustard)

Click for video on blistering agents (1)
http://www.youtube.com/watch?v=jGw0pyXROf4

### 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

Click for picture of blistering agent effects
http://www.college.ucla.edu/webproject/micro12/chemicalweapons/mustard2.jpg

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**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

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

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)

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

Click to see video on nerve agents (1.5)
http://www.youtube.com/watch?v=ZgVKCpdzZwc
Nerve agents
- Supportive treatment
  - endotracheal intubation
  - ventilation
  - bronchodilators - albuterol & ipratropium
  - tracheal suctioning
  - benzodiazepine 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
- 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

FYI - Click to see video about Chernobyl (3 min.)
http://www.youtube.com/watch?v=rwAJ_u3Q0Hw&feature=related
FYI - Click to see nuclear explosion (1.5)
http://www.youtube.com/watch?v=xIIIdmu92E&feature=related
**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
- x-rays - 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 ==>
    - carcinoma
    - teratogenesis (birth defects)

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

FYI - click to see Chernobyl birth defect
http://www.flickr.com/photos/susek/3061170039/
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

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

Explosions
Blast Injuries
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
FYI - click to download article on blast injuries
http://www.cdc.gov/masstrauama/preparedness/primer.pdf

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
FYI - Click to download blast injury Powerpoint. Scroll down to "Bombings - 1 hour module"
http://www.acep.org/blastinjury
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

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

Types of natural disasters
- Heat waves
- Blizzards/extreme cold
- Earthquakes - collapses, explosions
- Tsunamis
- Volcanic eruptions

FYI - Click for information on disaster death tolls

FYI - Click to see natural disaster risk map
http://www.harborinsurance.com/guides/disasterprofile.htm
FYI - Click to see video of earthquakes
http://www.youtube.com/watch?v=4Y-62Ti5_6s
### 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

### 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

### 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

FYI - Click for information on Project XTREME: http://www.ahrq.gov/prep/projxtreme/

### 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
- Transportation of supplies to facility may be crippled

FYI - click for strategic national stockpile (SNS) information
http://www.bt.cdc.gov/stockpile/

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
    - transports
    - temporary therapy
    - built-in regulator most desirable
  - large cylinders
    - individual long-term therapy
    - back-pressure feed units
    - manifolds can create multiple-patient capabilities

  Click to see emergency oxygen manifold
  [http://www.lifesavingsystemsinc.com/manif_hdcases.htm](http://www.lifesavingsystemsinc.com/manif_hdcases.htm)

- **Limitations**
  - facility storage capacity
  - transport difficulties

  Infectious events demand disinfection of cylinders before transport.

  Click to see another emergency oxygen manifold
  [http://www.dvrescue.com/Picture%20010.jpg](http://www.dvrescue.com/Picture%20010.jpg)

## Oxygen concentrators

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

  Click to see Medical Oxygen Generator Skid™
**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

Click to see Oxair™ oxygen generator (scroll down)

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

Click to see multiple-patient LOX systems
http://www.medlox.com/hs.php
FYI - click to see video on multiple-patient LOX system
http://www.metacafe.com/watch/2621871/penn_care_mass_oxygen_distribution_system_for_mass_casualty_incident/

**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)

Click to see Impact Univent Eagle 754 ventilator
Click to see Puritan-Bennett LP-10 ventilator
### Mass casualty ventilator requirements
- Approved for adult and pediatric patients
- Capability to operate without 50 PSIG source
- Battery life ≥ 4 hours
- Constant volume delivery
- CMV mode included
- Adjustable PEEP capability (5-15 cm H2O)

### 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
- 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

### 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

FYI - click to download article on mass casualty ventilation

<table>
<thead>
<tr>
<th><strong>Ventilators</strong></th>
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<tbody>
<tr>
<td><strong>Anesthesia ventilators</strong></td>
<td><strong>Negative pressure cuirass ventilators</strong></td>
</tr>
<tr>
<td>◆ some will be needed for emergency surgical procedures</td>
<td>◆ no intubation required - less risk of infection for caregivers</td>
</tr>
<tr>
<td>◆ managed by:</td>
<td>◆ some casualties require airways</td>
</tr>
<tr>
<td>◆ anesthesia personnel - availability of time?</td>
<td>◆ United Hayek MRTX™ has been tested as an option for application to patients by physicians at the scene</td>
</tr>
<tr>
<td>◆ respiratory therapists - require orientation to devices</td>
<td>◆ not available in U.S.A.</td>
</tr>
<tr>
<td>FYI - click to see video of Hayek MRTX™ in mass casualty <a href="http://www.unitedhayek.com/presentations/movies/id/3">http://www.unitedhayek.com/presentations/movies/id/3</a></td>
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<td><strong>Pressure-cycled, single-use ventilators</strong></td>
<td><strong>Bag-valve ventilators</strong></td>
</tr>
<tr>
<td>◆ non-constant volume delivery</td>
<td>◆ short-term support</td>
</tr>
<tr>
<td>◆ no alarms</td>
<td>◆ effective ventilation without electrical power</td>
</tr>
<tr>
<td>◆ not for unattended patients</td>
<td>◆ ventilation can be provided by ancillary staff, volunteers</td>
</tr>
<tr>
<td>◆ require 50 PSIG source</td>
<td></td>
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<tr>
<td>◆ use large amounts of gas</td>
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<tr>
<td>FYI - Click to see manual ventilation after Katrina <a href="http://ajrccm.atsjournals.org/content/vol172/issue10/images/large/2509004f1.jpeg">http://ajrccm.atsjournals.org/content/vol172/issue10/images/large/2509004f1.jpeg</a></td>
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<td>FYI - click to download article on healthcare and Katrina <a href="http://ajrccm.atsjournals.org/cgi/reprint/172/10/1239">http://ajrccm.atsjournals.org/cgi/reprint/172/10/1239</a></td>
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<th><strong>Ventilators</strong></th>
<th><strong>Organizational preparation</strong></th>
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<tr>
<td><strong>National stockpile ventilator kits</strong></td>
<td><strong>Maintain stocks of devices and supplies</strong></td>
</tr>
<tr>
<td>◆ kit includes ventilators, ventilator supplies, instructional media</td>
<td><strong>Plan for mass casualty events</strong></td>
</tr>
<tr>
<td>◆ airway management materials contained in 12 hour push packages</td>
<td><strong>Rehearse mass casualty scenarios</strong></td>
</tr>
<tr>
<td>◆ takes hours, to days for delivery</td>
<td><strong>Prepare and train ALL personnel for mass casualty events</strong></td>
</tr>
</tbody>
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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

References

References

- Daugherty EL. Health care worker protection in mass casualty respiratory failure: infection control, decontamination, and personal protective equipment. Respir Care. 2008 Feb;53(2):201-12.

References


References

http://www.dmphp.org/cgi/content/full/3/Supplement_1/S59

References