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.

Learning Objectives:
- Describe major types of natural disasters, their associated types of injuries, their manifestations and management.
- 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.

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 of 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

Management

- supportive - ventilation, O2
- antibiotics
  - doxycycline
  - ciproflaxin
  - 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.

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
  - 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

FYI - click to see *yersinia pestis*
http://img.docstoccdn.com/thumb/orig/107508116.png

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

Click to see disease carrier

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

Click to see tularemia cutaneous ulcer (rabbit bite)

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)

FYI - Click to download article on viral hemorrhagic fevers

**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
- 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
https://www.ouhsc.edu/ehso/training/images/PPEa.jpg

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

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

FYI - click for information on Montana chlorine spill
FYI - click for video on SC chlorine spill (3 min)
http://www.youtube.com/watch?v=OoDouOrQPAo

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 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

**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)

- **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

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

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

Click for picture of blistering agent effects
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

Nerve agents

Cholinergic crisis (see neuro lesson)

- Salivation
- Lacrimation
- Urination
- Diaphoresis
- GI distress (diarrhea, vomiting)
- Emesis
- Bronchospasm

Click to see video on nerve agents (1.5)
http://www.youtube.com/watch?v=ZgVKCpdzZwc

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

Pesticides; e.g.:
- Sevin
- diazinon
- malathione
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

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

FYI - Click to see video about Chernobyl (3 min.)
http://www.youtube.com/watch?v=rvAJ_u3Q0Hw&feature=related

FYI - Click to see video about nuclear explosion (1.5)
http://www.youtube.com/watch?v=xIIQmu7ZE&feature=related

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

Copyright 2010 AP Jones
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
Categories of 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

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

Types of natural disasters
- Floods - most common
- Hurricanes - wind, flooding, fires
- Tornadoes - wind
- Wild fires
- Avalanches/landslides/mudslides

Natural Disasters

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

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-6Zt5_6s
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

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

- 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

**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

- 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://archive.ahrq.gov/prep/projxtreme/

- 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

- 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

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**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

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**Oxygen cylinders**

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

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**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.penncare.net/DisasterResponseDivision/HospitalSurge/MassOxygenDistributionSystemMODS.aspx

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
http://www.websites.medmatrix.com/instrumentpics/3844.jpg
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)

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

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

- **Negative pressure cuirass ventilators**
  - No intubation required - less risk of infection for caregivers
  - Some casualties require airways
  - United Hayek MRTX™ has been tested as an option for application to patients by physicians at the scene
  - Not available in U.S.A.

FYI - click to see video of Hayek MRTX™ in mass casualty
http://www.unitedhayek.com/presentations/movies/id/3

- **Pressure-cycled, single-use ventilators**
  - Non-constant volume delivery
  - No alarms
  - Not for unattended patients
  - Require 50 PSIG source
  - Use large amounts of gas

- **Bag-valve ventilators**
  - Short-term support
  - Effective ventilation without electrical power
  - Ventilation can be provided by ancillary staff, volunteers

FYI - click to download article on healthcare and Katrina

- **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

References

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