

## Respiratory Care Emergency Preparedness For Mass Casualty Events

Arthur Jones, EdD, RRT

<http://rc-edconsultant.com/>

### Learning Objectives:

- △ Describe the healthcare situations and extended requirements associated with:
  - ◆ febrile respiratory illness; e.g., pandemic influenza, bioterrorism
  - ◆ natural disasters
  - ◆ man-made disasters
- △ Explain strategies to utilize in preparing for and responding to mass casualty events.

## 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??

**Influenza****▲ Management**

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

**Influenza****▲ Prevention**

- ◆ vaccination
- ◆ antiviral agents
  - ▶ amantidine
  - ▶ neuraminidase inhibitors
- ◆ airborne isolation of patients

FYI - Click for video with advice for flu management & prevention

<http://www.youtube.com/watch?v=zJ6VT7ciR1o>

**Influenza****▲ 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

**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

Click to see chest radiograph of pulmonary anthrax  
<http://www.ph.ucla.edu/epi/bioter/minafig1a.jpg>

**Pulmonary anthrax****▲ Diagnosis**

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

**Pulmonary anthrax****▲ Management**

- ◆ supportive - ventilation, O<sub>2</sub>
- ◆ 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)
  - ▶ 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://webs.wichita.edu/mschneegurt/biol103/lecture14/pestis\\_big.jpg](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

Click to see disease carrier

<http://disney-clipart.com/bambi/jpg/Thumper-1-ig.jpg>

**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)

[http://img.medscape.com/pi/emed/ckb/infectious\\_diseases/211212-230923-3447.jpg](http://img.medscape.com/pi/emed/ckb/infectious_diseases/211212-230923-3447.jpg)

**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

<http://jama.ama-assn.org/cgi/reprint/287/18/2391?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=vhf&searchid=1&FIRSTINDEX=0&resourcetype=HW>

**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)

**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

**Flow of patient care**

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

See flowchart in: Sandrock CE. Severe febrile respiratory illnesses as a cause of mass critical care. Respir Care. 2008 Jan;53(1):40-53

**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**
- ▲ **Level E - personal**

Click to see levels A - D personal protective equipment

You will need to scroll down the page.

<http://www1.va.gov/vasafety/page.cfm?pg=529>

Click to see level E personal protective equipment

<http://www.trojancondoms.com/Product/ProductDetails.aspx?ProductId=13>

**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**

**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  
<http://www.aristatek.com/newsletter/0704April/TechSpeak.aspx>

FYI - click for video on SC chlorine spill (3 min)  
<http://www.youtube.com/watch?v=ecEmm-ZSKU4>

FYI - click for video on Bhopal disaster (11 min.)  
<http://www.youtube.com/watch?v=Xz-BfXLjQ9c&feature=channel>

**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 O<sub>2</sub> (mild exposure)
  - ◆ bronchodilators
  - ◆ inhaled NaHCO<sub>3</sub> 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 O<sub>2</sub> 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
    - amyl nitrite
    - sodium nitrite
    - sodium thiosulfate
  - ◆ oxygen
  - ◆ hyperventilation
  - ◆ NaHCO<sub>3</sub>

**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>

**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

Click for picture of blistering agent effects  
<http://www.brownorigin.com/EODonAFMIL/Blister.jpg>

**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

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

**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 nuclear explosion (1.5)

<http://www.youtube.com/watch?v=rxlIDmuj8ZE&feature=related>

FYI - Click to see video about Chernobyl (3 min.)

[http://www.youtube.com/watch?v=rvAJ\\_u3Q0Hw&feature=related](http://www.youtube.com/watch?v=rvAJ_u3Q0Hw&feature=related)

**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 ==>
    - carcinoma
    - teratogenesis (birth defects)

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

**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

FYI - click to download article on blast injuries  
<http://www.simquest.com/HRC-blastNEJM.pdf>

**Secondary blast injuries**

- ▲ Caused by flying debris
- ▲ Penetrating and blunt force injuries to any body parts; e.g., open pneumothorax

Click to see a blast injury

<http://www.ddasonline.com/facewreck.jpg>

Click to see another blast injury

<http://www.ddasonline.com/handwreck.jpg>

**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 O<sub>2</sub>
- ▲ 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

FYI - Click for information on disaster death tolls  
[http://en.wikipedia.org/wiki/List\\_of\\_United\\_States\\_disasters\\_by\\_death\\_toll](http://en.wikipedia.org/wiki/List_of_United_States_disasters_by_death_toll)

**Types of natural disasters**

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

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](http://www.youtube.com/watch?v=4Y-62Ti5_6s)

**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

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

**Staff 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/>

**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., SpO<sub>2</sub> 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)

**Oxygen cylinders****^ 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>

**Oxygen concentrators****^ Mass casualty applications - large oxygen generators**

- ◆ refill cylinders
- ◆ back pressure feed units for capability of 93% O<sub>2</sub> at 50 PSIG

Click to see Medical Oxygen Generator Skid™  
[http://www.ogsi.com/hospital\\_supply\\_systems.php](http://www.ogsi.com/hospital_supply_systems.php)

**Oxygen concentrators****^ Mass casualty applications - large oxygen generators**

- ◆ refill cylinders
- ◆ back pressure feed units for capability of 93% O<sub>2</sub> at 50 PSIG

**^ Limitations**

- ◆ size - storage space
- ◆ require electricity
- ◆ expense

Click to see Oxair™ oxygen generator ( scroll down)  
[http://www.oxair.com.au/oxy\\_psa\\_generators.htm](http://www.oxair.com.au/oxy_psa_generators.htm)

**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/](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 FIO<sub>2</sub> and liter flows necessary
- ▲ use reservoir cannulae
- ▲ use gas-sparing ventilators
- ▲ use HME's for humidification
- ▲ target lower SpO<sub>2</sub>

**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

<http://www.msdonline.com/biomed/meh/images/LP10.JPG>

**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 H<sub>2</sub>O)

**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

[http://www.upmc-bioscience.org/etd/etdresources/publications/2006\\_orig/articles/2006\\_article\\_pdf/2006-06-15\\_positvepressureventilationformasscasualtyrespiration.pdf](http://www.upmc-bioscience.org/etd/etdresources/publications/2006_orig/articles/2006_article_pdf/2006-06-15_positvepressureventilationformasscasualtyrespiration.pdf)

**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™ 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/>

**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

FYI - Click to see manual ventilation after Katrina  
<http://ajrccm.atsjournals.org/content/vol172/issue10/images/large/2509004f1.jpeg>

FYI - click to download article on healthcare and Katrina  
<http://ajrccm.atsjournals.org/cgi/reprint/172/10/1239>

**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****References**

- ▲ Briggs SM, Brinsfield KH. Advanced disaster medical response: A manual for providers 2003. Harvard Medical International; Boston.
- ▲ Christian MD, Devereaux AV, Dichter JR, Geiling JA, Rubinson L. Definitive care for the critically ill during a disaster: current capabilities and limitations: from a Task Force for Mass Critical Care summit meeting, January 26-27, 2007, Chicago, IL. Chest. 2008 May;133(5 Suppl):8S-17S.
- ▲ Ben-Abraham R, Gur I, Bar-Yishay E, Lin G, Blumenfeld A, Kalmovich B, Weinbroum AA. Application of a cuirass and institution of biphasic extra-thoracic ventilation by gear-protected physicians. J Crit Care. 2004 Mar;19(1):36-41.

**References**

- ▲ Talmor D. Airway management during a mass casualty event. Respir Care. 2008 Feb;53(2):226-31.
- ▲ 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.
- ▲ O'Laughlin DT, Hick JL. Ethical issues in resource triage. Respir Care. 2008 Feb;53(2):190-7.
- ▲ Hanley ME, Bogdan GM. Mechanical ventilation in mass casualty scenarios. Augmenting staff: project XTREME. Respir Care. 2008 Feb;53(2):176-88; discussion 189.
- ▲ Little CM, Merritt M, Wentworth A. An improvised oxygen supply system for pandemic and disaster use. Acad Emerg Med. 2009 Jun;16(6):558-63.

**References**

- ^Wilgis J. Strategies for providing mechanical ventilation in a mass casualty incident: distribution versus stockpiling. *Respir Care*. 2008;53(1):96-100.
- ^Malatino EM. Strategic national stockpile: overview and ventilator assets. *Respir Care*. 2008 Jan;53(1):91-5.
- ^Branson RD, Johannigman JA, Daugherty EL, Rubinson L. Surge capacity mechanical ventilation. *Respir Care*. 2008 Jan;53(1):78-88.
- ^Hotchkiss DL, Rubinson L. Modified critical care and treatment space considerations for mass casualty critical illness and injury. *Respir Care*. 2008 Jan;53(1):67-74.
- ^Muskat PC. Mass casualty chemical exposure and implications for respiratory failure. *Respir Care*. 2008 Jan;53(1):58-63

**References**

- ^Sandrock CE. Severe febrile respiratory illnesses as a cause of mass critical care. *Respir Care*. 2008 Jan;53(1):40-53
- ^Branson RD, Rubinson L. Mechanical ventilation in mass casualty scenarios. *Respir Care*. 2008 Jan;53(1):38-9.
- ^Hick JL, Barbera JA, Kelen GD. Refining Surge Capacity: Conventional, Contingency, and Crisis Capacity. *Disaster Medicine and Public Health Awareness*; 2009 0: DMP.0b013e31819f1ae2. [http://www.dmph.org/cgi/content/full/3/Supplement\\_1/S59](http://www.dmph.org/cgi/content/full/3/Supplement_1/S59)
- ^Ritz RH, Previtera JE. Oxygen supplies during a mass casualty situation. *Respir Care* 2008;53:215-224.
- ^Loeb M, et al. Surgical mask vs. N95 respirator for preventing influenza among healthcare workers. *JAMA* 2009; 302:1865-1871.

**References**

- ^Rubinson L, et al. Definitive care for the critically ill during a disaster: medical resources for surge capacity: from a Task Force for Mass Critical Care summit meeting, January 26-27, 2007, Chicago, IL. *Chest*. 2008 May;133(5 Suppl):32S-50S.
- ^Hui DS, Hall SD, Chan MT, Chow BK, Ng SS, Gin T, Sung JJ. Exhaled air dispersion during oxygen delivery via a simple oxygen mask. *Chest*. 2007 Aug;132(2):540-6. Epub 2007 Jun 15.
- ^Hui DS, Chow BK, Ng SS, Chu LC, Hall SD, Gin T, Sung JJ, Chan MT. Exhaled air dispersion distances during noninvasive ventilation via different Respironics face masks. *Chest*. 2009 Oct;136(4):998-1005. Epub 2009 May 1.