

# Biological Agents

## Anthrax

### Etiology & Transmission

- Caused by *Bacillus anthracis*: a spore forming gram-positive bacillus
- Occurs most frequently in sheep, goats and cattle, by ingesting contaminated soil
- Humans can become infected by ingesting, inhaling or having skin contact with spores from infected animals or animal products (as in “wool sorter’s disease” from exposure to goat hair)
- Person-to-person transmission of pulmonary disease does not occur, but direct exposure to vesicle secretions of cutaneous anthrax lesions may result in secondary cutaneous infection

### Clinical features

- Three forms: pulmonary, cutaneous, or gastrointestinal; pulmonary form is associated with bioterrorism exposure to aerosolized spores

#### Pulmonary

- prodrome of **flu-like symptoms** following inhalation of infectious spores
- 2 to 4 days after initial symptoms, abrupt onset of respiratory failure and hemodynamic collapse, widened mediastinum on chest radiograph suggestive of mediastinal lymphadenopathy and hemorrhagic mediastinitis
- Gram-positive bacilli on blood culture, usually after the first 2 or 3 days of illness
- High mortality if treatment initiated after onset of respiratory symptoms

#### Cutaneous

- Local skin involvement (head, forearms or hands) after direct contact with spores or bacilli
- Usually non-fatal if treated with antibiotics

#### Gastro-intestinal

- Abdominal pain, nausea, vomiting, bloody diarrhea and fever following ingestion of contaminated food, usually meat
- Usually fatal after progression to toxemia and sepsis

### Incubation period

- 2 to 60 days following pulmonary exposure
- 1 to 7 days following cutaneous exposure
- 1 to 7 days following ingestion

## Protection Measures - Vaccine

- Limited availability of inactivated, cell-free anthrax vaccine (Bioport Corporation (517) 327-1500, formerly Michigan Biologic Products Institute\*)
- Routinely administered only to military personnel. Routine vaccination of civilian populations not recommended

## Post Exposure Management

### Decontamination of patients/environment

- Instruct patients to remove contaminated clothing and store in labelled plastic bags
- Minimize handling of clothing to avoid agitation of spores
- Instruct patients to shower thoroughly with hypoallergenic soap and water (provide assistance, using sponges, if necessary)
- Instruct personnel to use Routine Practices and wear appropriate barriers (e.g., gloves, gown, masks) when handling contaminated clothing or fomites
- Decontaminate environmental surfaces using a facility-approved sporicidal/germicidal agent or 0.5% hypochlorite solution (one part household bleach to nine parts water)

### Prophylaxis and post-exposure immunization

- Recommendations for prophylaxis are subject to change. Consult MOHLTC and PHAC for up to date recommendations
- Initiate prophylaxis upon confirmation of an anthrax exposure.

Antimicrobial agent	Adults	Children, Pregnant and Lactating Women§
Oral Fluoroquinolones - one of the following: <ul style="list-style-type: none"> <li>• Ciprofloxacin</li> <li>• Levofloxacin</li> <li>• Ofloxacin</li> </ul>	500 mg twice daily  500 mg once daily 400 mg twice daily	20 to 30 mg per kg of body mass daily, divided into two doses (Max. 500 mg twice daily)  Not recommended Not recommended
<i>Or</i> Doxycycline	100 mg twice daily	5 mg per kg of body mass daily, divided into two doses (Max. 100 mg twice daily)

§ Use of fluoroquinolones and tetracyclines in children, pregnant or lactating women is associated with adverse effects that must be weighed against the risk of developing a lethal disease. Discuss with an infectious disease consultant or local public health officials.

If *B. anthracis* exposure is confirmed, test the organism for penicillin susceptibility.

If susceptible, exposed children, pregnant and lactating women may be treated with oral amoxicillin 40 mg per kg of body mass per day divided every 8 hours (not to exceed 500 mg, three times daily). Prophylaxis should continue until *B. anthracis* exposure has been excluded.

If exposure is confirmed, continue prophylaxis for 8 weeks (or according to current best evidence). In addition to prophylaxis, post-exposure immunization with an inactivated, cell-free anthrax vaccine may also be indicated following anthrax exposure.

If available, and according to current best evidence, post-exposure vaccination consists of three doses of vaccine at 0, 2 and 4 weeks after exposure.

## **Triage and management of large scale exposures /potential exposures**

Advance planning by local public health department should include identification of:

- Sources of prophylactic antibiotics and planning for acquisition on short notice
- Locations, personnel needs and protocols for administering prophylactic post-exposure care to large numbers of potentially exposed individuals
- Means for providing telephone follow-up information and other public communications services

## **Laboratory Support and Confirmation**

- Diagnosis confirmed by aerobic culture performed in a BSL-3 laboratory
- Diagnostic samples include: blood cultures, acute serum for frozen storage, and stool culture if GI disease suspected
- Coordinate specimen handling, packaging and transport with Central Public Health Laboratory and the police or RCMP
- A chain of custody document should accompany the specimen from the moment of collection

## **Infection Prevention and Control Practices**

Use Routine Practices for:

- Patient care (i.e., routine use of gloves for contact with nonintact skin, including rashes and skin lesions)
- Cleaning, disinfection, and sterilization of equipment and environment
- Post-mortem care (i.e., wearing appropriate personal protective equipment, including masks and eye protection, when generating aerosols or body fluid splatters)

# Botulism

## Etiology & Transmission

- Anaerobic gram-positive bacillus that produces a potent neurotoxin that inhibits the release of acetylcholine, causing characteristic flaccid paralysis
- Spores are present in soil and marine sediment throughout the world
- Mainly transmitted by ingesting toxin-contaminated food; can also be transmitted in aerosolized form that can be inhaled. Both forms can be used as agents of bioterrorism.
- Not transmitted from person-to-person.

## Clinical features

- Initial GI symptoms if foodborne
- Cranial neuropathies (difficulty swallowing or speaking, double vision)
- Blurred vision and absence of pupillary reflexes
- Symmetric descending weakness (arms followed by respiratory muscles, then legs)
- Respiratory dysfunction from muscle paralysis or upper airway obstruction due to weakened glottis
- No sensory deficits

## Incubation period

- Neurological symptoms 12 to 36 hours after ingestion
- Neurological symptoms 24 to 72 hours after aerosol exposure

## Preventive Measures - Vaccine

- A pentavalent toxoid vaccine (developed by the US Department of Defence) is available as an investigational new drug (contact USAMRIID, 301-619-2833); induces protective antitoxin levels detectable 1-year post vaccination
- Routine immunization of the public, including healthcare workers, not recommended

## Post Exposure Management

- One suspect case may indicate outbreak associated with shared contaminated food; locate contaminated food source and identify others who may have been exposed
- Monitor anyone who may have been exposed for respiratory compromise

### Decontamination of patients / environment

- Not required

### Prophylaxis and post-exposure immunization

- Physicians suspecting botulism should contact their local MOH who will arrange through the provincial Ministry of Health (public health or pharmacy) to obtain

antitoxin through the Health Canada Special Access Program. Antitoxin is prepositioned in several provinces for ease of shipping however the Health Canada SAP request must still be completed.

- Perform skin testing according to the package insert before administering

#### **Triage and management of large scale exposures / potential exposures**

- Patients with respiratory dysfunction often require mechanical ventilation for up to 2 to 3 months
- Advanced planning should be undertaken for large-scale exposures that may require surge capacity beyond an individual facility or community

#### **Laboratory Support and Confirmation**

- Limited value in diagnosis
- Detection possible from serum, stool samples, or gastric secretions; for advice on appropriate specimens, contact the local laboratory or Central Public Health Laboratory

#### **Infection Prevention and Control**

- Not spread person to person
- Use Routine Practices for patient care and cleaning, disinfection and sterilization of equipment and environment

# Plague

## Etiology & Transmission

- Caused by gram-negative bacillus *Yersinia pestis*, usually transmitted to humans from infected fleas
- Causes lymphatic and blood infections (bubonic and septicemia plague)
- Terrorism-related outbreak possible through inhalation of droplets (i.e., pneumonic plague)
- Person-to-person transmission of pneumonic plague possible via large droplets

## Clinical features

- Fever, cough, chest pain, Hemoptysis
- Muco-purulent or watery sputum with gram-negative rods on gram stain
- Radiographic evidence of bronchopneumonia

## Incubation period

- 2 to 8 days for fleaborne transmission
- 1 to 3 days for pulmonary exposure

## Preventive Measures - Vaccine

- Formalin-killed vaccine effective for bubonic plague, but not pneumonic plague
- Requires multiple doses given over several weeks; not recommended for general public
- Post-exposure immunization not effective

## Post Exposure Management

### Decontamination of patients / environment

In cases of gross contamination:

- instruct patients to remove contaminated clothing and store in labelled plastic bags
- Minimize handling of clothing to avoid aerosolization of droplets
- Instruct patients to shower thoroughly with hypoallergenic soap and water (provide assistance, using sponges, if necessary)
- Instruct personnel about Routine Practices and wearing appropriate barriers (e.g., gloves, gown, respiratory protection) when handling contaminated clothing or fomites
- Decontaminate environmental surfaces using a facility-approved sporicidal/germicidal agent or 0.5% hypochlorite solution (one part household bleach to nine parts water)

### Prophylaxis

- Initiate post-exposure prophylaxis following confirmed or suspected bioterrorism exposure, and for healthcare workers and others who had unprotected face-to-face contact with symptomatic patients
- Recommendations for prophylaxis are subject to change. Contact the MOHLTC and PHAC for up-to-date recommendations

Antimicrobial agent	Adults	Children §
Doxycycline	100 mg twice daily	5 mg per kg of body mass per day divided into two doses
Ciprofloxacin	500 mg twice daily	20-30 mg per kg of body mass daily divided into two doses

*§ Pediatric use of tetracyclines and flouoroquinolones is associated with adverse effects that must be weighed against the risk of developing a lethal disease.*

*Prophylaxis should continue for 7 days after last known or suspected *Y. pestis* exposure, or until exposure has been excluded.*

### Triage and management of large scale exposures / potential exposures

As part of advance planning, identify

- Sources for appropriate Droplet Precaution masks for potentially large number of patients and staff
- Sources of bulk prophylactic antibiotics and planning for acquisition on short notice.
- Locations, personnel needs and protocols for administering prophylactic post-exposure care to large numbers of potentially exposed individuals.
- Means for providing telephone follow-up information and other public communications services

### Laboratory Support and Confirmation

- Laboratory confirmation by standard microbiologic culture, but slow growth and misidentification in automated systems likely to delay diagnosis
- Diagnostic samples include: serum for capsular antigen testing, blood cultures, sputum or tracheal aspirates for Gram's, Wayson's, and fluorescent antibody staining, sputum or tracheal aspirates for culture
- Coordinate specimen handling, packaging and transport with Central Public Health Laboratory and the police or RCMP
- A chain of custody document should accompany the specimen from the moment of collection

### Infection Prevention and Control

- Use Droplet Precautions and Routine Practices for patients with pneumonic plague
- Maintain Droplet Precautions until patient has completed 72 hours of antimicrobial therapy

# Smallpox

## Etiology & Transmission

- Caused by the variola virus, which can be transmitted from person-to-person via airborne and droplet exposure, and by contact with skin lesions or secretions
- Patients more infectious if they are coughing or have a hemorrhagic form of smallpox
- Patients infectious from onset of rash and until scabs separate (approximately 3 weeks)
- Last naturally acquired case of smallpox > 20 years ago
- If used as terrorism agent, has potential to cause severe morbidity in a non-immune population: a single case is a public health emergency

## Clinical features

- Acute clinical symptoms resemble other viral illnesses, such as influenza
- Skin lesions quickly progress from macules to papules to vesicles
- 2 to 4 day, non-specific prodrome of fever, myalgias
- rash most prominent on face and extremities (including palms and soles)
- rash scabs over in 1 to 2 weeks

## Incubation period

- 7 to 19 days (commonly 10-14 days to onset of illness and 2-4 more days to onset of rash)

## Preventive Measures - Vaccine

- Live-virus intradermal vaccination available in limited quantities from Health Canada
- Routine vaccination not recommended due to no natural risk
- **Vaccination does not reliably confer lifelong immunity: previously vaccinated persons considered susceptible to smallpox**

## Post Exposure Management

### Decontamination of patients / environment

- Not indicated
- Use Contact Precautions to handle items potentially contaminated by infectious lesions

### Prophylaxis and post-exposure immunization

- Recommended prophylaxis subject to change. Contact MOHLTC and PHAC for up-to-date recommendations
- Within 3 days of exposure, immunize with smallpox vaccine (vaccinia virus) alone
- If >3 days since exposure, immunize with smallpox vaccine AND vaccinia immune-globulin (VIG) (0.6ml/kg IM)

- Vaccination contraindicated in pregnant women, and persons with immunosuppression, HIV–infection, and eczema, who are at risk for disseminated vaccinia disease. Weigh risk of smallpox vaccination against the likelihood of developing smallpox following a known exposure. VIG should be given concomitantly with vaccination in these patients
- Arrange vaccine supplies through MOHLTC in conjunction with PHAC.
- Monitor individuals who receive prophylaxis for flu-like symptoms, fever or rash during incubation period (i.e., 7 to 17 days after exposure); if symptoms develop, manager patient as a case
- Establish policies to identify and manage health care workers exposed to infectious patients (e.g., maintaining accurate occupational health records).

#### **Triage and management of large scale exposures / potential exposures**

- Work with facilities to identify sites that can maintain Airborne Precautions.

#### **Laboratory Support and Confirmation**

- Testing performed only in BSL-4 laboratories
- Coordinate with Central Public Health Laboratory, PHAC, police and Department of National Defense on the collecting, handling, and transporting of specimens
- A chain of custody document should accompany the specimen from the moment of collection

#### **Infection Prevention and Control**

- Use Airborne Precautions, Contact Precautions and Routine Practices

# Tularemia

## Etiology & Transmission

- Caused by *F. tularensis*, a small gram-negative non-spore-forming bacillus that can persist for weeks or months in mud, water, and decaying animal carcasses
- Carried by biting and blood-sucking insects, especially ticks and tabanid flies, and by animals, such as wild rabbits, squirrels, birds, sheep, beavers, muskrats, and domestic dogs and cats
- Humans usually infected through insect bites, handling infected animal tissues/fluids, and direct contact with or ingestion of contaminated water, food, or soil. Most cases in rural areas in the south-central and western states from June through September (tick season) and usually hunters
- Can be inhaled: small number of bacteria can cause disease
- No person-to-person transmission

## Clinical features

- Sudden fever, chills, headaches, diarrhea, muscle aches, joint stiffness or pain, dry cough
- Progressive weakness leads to a dry cough and pneumonia, which can cause chest pain, bloody sputum (phlegm), and trouble breathing
- Other symptoms may include a red spot on the skin that enlarges to an ulcer, ulcers in the mouth, swollen and painful lymph glands, swollen and painful eyes, and sore throat
- If left untreated, can lead respiratory failure, shock, and death

## Incubation period

- Usually 3 to 5 days but can take several weeks to develop pneumonia

## Preventive Measures – Vaccine

- Experimental vaccine currently used only by laboratory and other high risk workers
- Routine public vaccination not recommended

## Post Exposure Management

### Decontamination of patients / environment

- Not required

### Prophylaxis

- Treat with antibiotics in early stages of infection, such as doxycycline or ciprofloxacin

### Triage and management of large scale exposures / potential exposures

- Treat cases of tularaemia in regions where disease is not prevalent as possible outbreak

- Assess epidemiological, clinical, and microbiological findings for intentional tularaemia
- Identify source of bacteria and prescribe antibiotics for anyone with possible exposure

### **Laboratory Support and Confirmation**

- Send blood and other specimens to Provincial Lab

### **Infection Prevention and Control**

- Routine Practices

# Viral Hemorrhagic Fever

## Etiology & Transmission

- Caused by group of RNA viruses (Filoviridae, Arenaviridae, Bunyaviridae, Flaviviridae)
- Greatest bioterrorism threats are **Ebola** and **Marburg** (filovirus family)
- Droplet spread from person-to-person: risk greater in latter stages of illness when virus loads are high
- Can be aerosolized and highly infectious at low dose by aerosol

## Clinical features

- Abrupt onset of fever, myalgias, headache, malaise, arthralgias, nausea, diarrhea, and abdominal pain
- May develop conjunctivitis, pharyngitis, and a rash
- As diseases progress, worsening bleeding diathesis, with petechiae, conjunctival and mucosal hemorrhage, hematuria, hematemesis, and melena, followed by DIC and hypotension
- Delirium, seizures, and coma; shock and multiple organ system failure presage death.
- Case fatality rates range from <5% to up to 90% with Ebola Zaire subtype

## Incubation period

- 2 to 21 days depending on the viral agent

## Preventive Measures – Vaccine

- No licensed vaccine available except for yellow fever
- Yellow fever vaccine effective when given in advance but NOT after exposure

## Post Exposure Management

### Decontamination of patients / environment

- Clean environmental surfaces and contaminated equipment (1:10 to 1:100)
- Dilution of household bleach or other EPA-registered disinfectant)
- Handle clothing and linens per guidelines

### Prophylaxis

- Treat VHF of unknown etiology with intravenous Ribavirin therapy (available from MOHLTC or PHAC)
- Ribavirin effective against Lassa Fever and some new world Arenaviruses but **not** against Filoviruses or Flaviviruses
- Ribavirin contraindicated in pregnancy

### **Triage and management of large scale exposures / potential exposures**

- Instruct people with percutaneous or mucocutaneous exposures to blood, body fluids, secretions, or excretions from a patient with suspected VHF to wash affected skin surfaces with soap and water and rinse eyes with copious amounts of water or eyewash solution
- Follow exposed persons and monitor fever twice daily for 21 days after exposure.
- Consult infectious diseases expert if exposed person develops fever within 21 days of exposure

### **Laboratory Support and Confirmation**

- Testing performed only in BSL-4 laboratories
- Coordinate with Central Public Health Laboratory, PHAC, police and Department of National Defense on the collecting, handling, and transporting of specimens
- A chain of custody document should accompany the specimen from the moment of collection

### **Infection Prevention and Control**

- Use Droplet Precautions, Contact Precautions and Routine Practices
- Consider Airborne Precautions for patients with severe pulmonary involvement or having procedures that stimulate coughing and promote the generation of aerosols

# Chemical Agents

## Nerve Agents

### Types and mode of action

- Include sarin gas (GB), soman (GD), tabun (GA), pesticides
- Vapour form absorbed rapidly through respiratory tract; liquid absorption through skin, GI tract and eyes
- Inhibit Acetylcholinesterase, both nicotinic and muscarinic effects
- Attack nervous system and interfere with normal chemical instructions to nerves, muscles and glands

### Clinical features

- Excess secretions of glands
- SLUDGE: Salivation, Lacrimation, Urination, Defecation, GI upset, Emesis (muscarinic)
- Muscles twitch uncontrollably and repetitively; profound muscle weakness (nicotinic)
- Pinpoint pupils, decreased level of consciousness
- Bradycardia, increased or decreased blood pressure

### Time to onset of symptoms

- Within 20 minutes if gas/vapour release
- If no symptoms within 20 minutes, assume no vapour organophosphate exposure

### Management

#### Decontamination of patients / environment

- Persons whose skin or clothing is contaminated with nerve agent can contaminate rescuers by direct contact or through off-gassing vapor; persons whose skin is exposed only to nerve agent vapor pose no risk of secondary contamination; however, clothing can trap vapor
- Decontaminate patients and environment if possible
- Remove people from area

#### Antidotes/Treatment

- Atropine blocks receptors, reduces secretions and can be life-saving; required in large doses (5 to 20 mg) to treat organophosphate exposure
- However in small doses (2 mg), produces symptoms in non-affected persons (blurred vision, mydriasis, tachycardia, dry eyes and skin); therefore only administer until secretions dry and ventilation easier; in severe exposure, administer before other airway measures to reduce secretions

- Pralidoxime (600 to 1800 mg) to block excess nicotinic activity (muscle stimulation): only useful within 3 hours of exposure
- Diazepam (lorazepam, midazolam) if needed for muscle rigidity/seizures; in severe exposure, administer before seizures; other anticonvulsants **not** effective

Moderate Symptoms	Severe Symptoms/Exposure
<p><b>Initial:</b></p> <ul style="list-style-type: none"> <li>• Atropine 4 mg</li> <li>• Pralidoxime [2-Pam] 1200 mg</li> </ul> <p><b>Ongoing:</b></p> <ul style="list-style-type: none"> <li>• Atropine until secretions controlled</li> <li>• Pralidoxime maximum 1800 mg</li> </ul>	<ul style="list-style-type: none"> <li>• Atropine <math>\geq</math> 6 mg.</li> <li>• Diazepam 10 mg (not if apneic)</li> <li>• Decontaminate &amp; early transport to hospital</li> </ul>

- Antidotes not tolerated well by elderly patients: consider half doses and monitor
- Antidotes tolerated well by children: give half doses if  $\leq$  8 years or  $\leq$ 30 kg.

### **General Measures**

- Protect responders from exposure
- Protect other victims
- Maintain ABCs

## **Blood agents (Cyanide)**

### **Types and mode of action**

- Found in many industrial agents; easy to obtain
- Can be inhaled and absorbed through other routes
- Chemical asphyxiant: interferes with cellular respiration by inhibiting cytochrome oxidase
- Exposure to 300 ppm fatal
- Potential for use in terrorist activities

### **Clinical features**

- Headache, confusion, seizures, coma, cardiac arrest within 8 minutes
- Severe respiratory distress, normal colour
- “Bitter almond” smell detected by only 50% of people
- Recovered patients may exhibit Parkinsonian syndrome

### **Time to onset of symptoms**

- Usually within 8 minutes in significant exposure

### **Management**

#### **Decontamination of patients / environment**

- If poorly ventilated inhalation exposure, responders must use Air Purifying Respirators
- If ventilated or ingested, no external decontamination

#### **Antidotes/Treatment**

- “Lilly” Kit: amyl nitrite, sodium nitrite and sodium thiosulfate
- Amyl nitrite inhalation (fast) sodium nitrite converts Hb into methemoglobin and frees enzyme BUT methemoglobin toxic; requires IV and 1% Methylene blue
- Sodium Thiosulfate (slow): chelates remaining cyanide to form thiocyanate (harmless and excreted in urine)
- Hydroxycobalamin (converts cyanide into harmless cyanocobalamin) available through special access programs in Canada

#### **Triage and management of large scale exposures / potential exposures**

- Antidotal therapy expensive and hard to obtain, store and use, and must be administered within minutes
- Moderate mass exposures may require prolonged therapy and ventilation

## Blister agents/Vesicants (Mustard Gas)

### Types and modes of action

- Include sulfur mustard, lewisite, nitrogen mustard
- Sulfur mustards are yellow to brown oily liquids with a slight garlic or mustard odor; others are odorless and colourless
- Although volatility is low, vapors can reach hazardous levels during warm weather; can be released in gas form
- Persist in environment for weeks
- Damages skin and mucous membranes

### Clinical features

- Blisters and erythema on skin, eyes
- Long-term ocular sequelae
- Damage to respiratory tract epithelium; cough and respiratory failure

**Table 1. Clinical Effects and Time of Onset by Severity of Exposure to Sulfur Mustard**

Tissue	Severity of exposure	Clinical effects	Time to first effect
Eyes	Mild	Tearing, itching, burning, gritty feeling	4-12 hours
	Moderate	Above effects and reddening, lid edema, moderate pain	3-6 hours
	Severe	Marked lid edema, possible corneal damage, severe pain	1-2 hours
Airways	Mild	Rhinorrhoea, sneezing, epistaxis, hoarseness, hacking cough	6-24 hours
	Severe	Above effects and productive cough, mild to severe dyspnea	2-6 hours
Skin	Mild	Erythema	2-24 hours
	Severe	Erythema and vesication	2-24 hours

### Time to onset of symptoms

- Effects for 12 hours indicate ongoing exposure

### Management

#### Decontamination of patients / environment

- People whose skin or clothing is contaminated with sulfur mustard can contaminate rescuers by direct contact or through off-gassing vapor.
- Decontaminate environment using copious amounts of water
- Keep people away from area until decontamination is complete

#### Antidotes/Treatment

- Copious washing and dilution
- Decontaminate skin using Reactive Skin Decontamination Lotion (RSDL); available under special access program at Public Health Agency of Canada

- Irrigate eyes with normal saline
- Intubate patients with severe respiratory distress and secretions
- Administer analgesics
- BAL lewisite antidotal therapy

**Triage and management of large scale exposures / potential exposures**

- Mass decontamination and monitoring

## **Choking Agents (HCl, Cl<sub>2</sub>, NH<sub>3</sub>)**

### **Types and modes of action**

- Include chlorine, phosgene, ammonia.
- Can be aerosolized (chlorine becomes greenish-yellow gas) and inhaled; heavier than air but non-persistent
- Powerful irritants that damage bronchioles and lung tissue

### **Clinical features**

- Mild exposure: eye and mucous membrane irritation
- Moderate/exposure: pulmonary edema
- Cough, gagging, chest tightness, shortness of breath
- Bronchospasm, ARDS

### **Time to onset of symptoms**

- Pulmonary edema in 2 to 4 hours (moderate exposure), 30 minutes (severe exposure)

### **Management**

#### **Decontamination of patients / environment**

- Copious water to decontaminate area

#### **Antidotes/Treatment**

- No antidotes
- Clear airways, provide oxygen
- Use bronchodilators, ventilation (PEEP)

#### **Triage and management of large scale exposures / potential exposures**

- Mass exposures may require prolonged therapy and ventilation
- Mass decontamination and monitoring

# Radiation Exposure

## Ionizing Radiation

Adapted from UK Health Protection Agency

Full document available at: <http://www.hpa.org.uk/emergency/pdfs/radiation.pdf>

### Etiology & Transmission

- Natural radiation (ionizing and non-ionizing) is all around us: in air, from cosmic rays; in the earth and building materials; and in food and water
- Man-made sources of radiation and radioactive materials are used in medicine (diagnostic imaging, radiotherapy), research, widely in industry (nuclear power stations, mining, food irradiation), industrial radiography (eg of pipes, buildings, baggage), smoke detectors and for many other uses including nuclear fuel and nuclear weapons

Four Types of Radioactive Materials:

- **Alpha** particles: heavy and highly charged, and interact strongly with atoms; as a result, they lose momentum rapidly, can travel only short distances and cannot penetrate human skin; hazardous only when inhaled, ingested, injected or absorbed (e.g. through a wound)
- **Beta** particles are also charged, but interact less strongly than alpha particles, so travel further and penetrate more: clothing, including standard PPE, provides some protection; can cause radiation skin injury on prolonged exposure but are hazardous to internal organs only when inhaled, ingested, injected or absorbed
- **Gamma** rays and **X-rays** are uncharged, so do not interact directly with atoms, and travel many metres in air; easily penetrate the human body, causing organ damage; effects can be attenuated by concrete or lead shielding
- **Neutrons** are uncharged, travel far and penetrate everything (except thick layers of concrete and water), and are highly damaging, but only likely to be produced in the very early stages of a nuclear detonation or accident
- **Contamination** occurs when radioactive material is deposited on skin and/or clothing (**external contamination**), or into the body (**internal contamination**) by inhalation, ingestion (hand-to-mouth, food, drink), or absorption via a wound
- **Exposed** patients who are not contaminated **do not** pose a threat to health care workers, in the same way that a patient who has had a CT scan or X-ray presents no risk to others; contaminated patients may (or may not) pose a threat, depending on the type of particle/ray and internal vs. external contamination

### Clinical features

- Local exposures may cause partial body injury (early erythema followed by bullae, and, if severe, ulceration and necrosis, often of the hands) and may not be associated with Acute Radiation Sickness (ARS)

- ARS follows a large, usually external exposure of the body to penetrating radiation (gamma rays, high-energy X-rays, neutrons) in a **short** time (seconds, minutes or hours) four-phase sequence: 4 phases: prodromal phase → latent period → illness → recovery/death
- As the radiation dose increases, the prodromal and latent periods shorten; severity of illness and mortality increase
- Major trauma and radiation exposure interact synergistically on mortality
- Initial symptoms of ARS are non-specific, and rarely immediately life-threatening; treatment of other injuries takes priority; if, in the first 6 hours after a suspected exposure, there are no symptoms of exposure (e.g. nausea, vomiting), serious ARS is unlikely

## Radiation Facts

- Radioactivity (and contamination by radioactive material) is measured in becquerels (1 Bq = 1 disintegration per second)
- The **absorbed dose** of radiation (the amount of energy absorbed by per unit mass of tissue) is measured in gray (Gy); 1 Gy = 1 joule/kg of tissue
- Different types of radiation have different effects on human tissue (alpha particles and neutrons are more damaging than beta particles, gamma rays or X-rays), so the absorbed dosage is multiplied by a radiation weighting factor to account for this, i.e. **equivalent dose** (of an organ or tissue), measured in sievert (Sv); for X-rays, gamma rays, and beta particles, the weighting factor = 1, so: 1 gray = 1 sievert = 1,000 millisievert
- Some organs are more radiosensitive than others (e.g. bone marrow is more sensitive than thyroid), and exposures are rarely uniform
- An estimate of the **whole body dose** is helpful in estimating long term cancer risk
  - Chest X-ray: 20 microsievert
  - Average annual background radiation: 2.2 millisievert (2,200 microsievert)
  - Annual effective dose limit for member of the public: 1 millisievert (1,000 microsievert)
  - Annual effective dose limit for radiation worker: 20 millisievert (20,000 microsievert)
  - Acute radiation sickness (whole body single dose):  $\geq 1$  sievert
  - LD50/60 dose killing 50% of those exposed within 60 days if not treated (whole body dose):  $\sim 4.5$  sievert

## Protection Measures

- Three key factors affect exposure: **duration, distance** and **shielding**; if the exposure duration is halved, the dose is halved; the inverse square law applies to distance: e.g. doubling the distance between the source and the body reduces the dose 4-fold
- Shielding can be accomplished by sheltering in place; barrier protection is effective against alpha and beta radiation

## Post Exposure Management

- **Triage and treat life-threatening injury before decontamination**; if the patient's clinical condition permits, decontaminate first, and then treat
- If trauma cases require surgery, perform as soon as possible (and certainly within 48 hours) if dose is more than 1 sievert

- Assume all patients are contaminated until ruled out: make sure that you, and surrounding area, are protected from possible contamination (wear PPE); reassign pregnant staff; do not handle unfamiliar objects or embedded fragments (e.g. shrapnel) directly: use tongs or forceps and place in lead-lined container; remember distance & inverse square law
- If possible assess contamination using contamination meter; if present, decontaminate, and presume patient may also be internally contaminated
- Treat nausea/vomiting symptomatically
- Obtain information to assist in assessing dose received (type of exposure, distance from event, duration of exposure, time of symptom onset)
- Document all injuries, sites of skin erythema, burns
- Obtain blood samples: baseline CBC with serial absolute lymphocyte counts 3-4 hourly for first 12 hours after acute exposure, then 6 hourly for 48 hours; HLA typing (before transfusing – use irradiated blood products if ARS possible); nasal swabs or nose blows x 2; chromosome analysis (7 ml venous blood taken 24 hours post exposure into lithium heparin tube); 24 hour urine and feces; seek expert advice on formal dose assessment and management of internal contamination if appropriate: infection-prevention regimes, growth factors, transfusions

#### **Decontamination of patients/environment**

- Instruct patients to remove contaminated clothing; double bag and store securely
- Minimize handling of clothing to avoid agitation of spores
- Instruct patients to shower thoroughly with hypoallergenic soap and water (provide assistance, using sponges, if necessary)
- Instruct personnel to use Routine Practices and wear appropriate barriers (e.g., gloves, gown, masks) when handling contaminated clothing

#### **Post-exposure Management: Potassium Iodide (KI)**

- Iodine prophylaxis should be considered in a radiological event involving radioactive iodine; however it must be stressed that sheltering and evacuation provide a much greater degree of protection (see above); potassium iodide only mitigates the effects on the thyroid gland of ingested or inhaled radioactive iodine
- KI may be distributed to those within 10 kilometres of an event determined to be over predetermined threshold of release (100 millisieverts according to PHAC)

#### Recommended single dosage of stable iodine according to age group

Age Group	Recommended quantity of elemental iodine (mg) <sup>1</sup>	Corresponding dose Potassium Iodide (KI) (mg)
Adults and adolescents <sup>2</sup> (over 12 years)	100	130
Children (3 – 12 years)	50	65
Infants (1 month – 3 years)	25	32
Newborns (< 1 month)	12.5	16

1 A 65 mg tablet of potassium iodide contains 50 mg of iodine.

2 For logistical simplicity in dispensing and administering KI, the U.S. FDA recommends a standard dose of 65 mg for all school age children, while allowing for the adult dose (130mg) in adolescents approaching adult size (FDA 2001); some authorities do not recommend treatment for adults > age 40, with the exception of pregnant or lactating females