Procedures for Medical Emergencies Involving Radiation *

RADIATION EMERGENCY ALERT

If there is a call that radiation accident victims will be sent to the hospital, immediately notify the nuclear medicine department, health physicist, radiation safety officer and others who will be concerned with patient treatment.

In order to determine if a patient is contaminated, the ambulance and the patient should be monitored before being brought into the emergency room. If the patient is contaminated, take the patient to a designated room in the emergency department. If the patient has received external radiation exposure only and is not contaminated, normal trauma procedures can be used.

Place any floor covering used to control contamination.

Persons doing the monitoring, as well as the triage officer, should wear surgical scrub suits with gloves, shoe covers, and film badges and/or pocket dosimeters.

EMERGENCY SUPPLIES

In the event of a radiation emergency involving contamination, bring the following supplies to the corridor outside the emergency room or to an adjacent room:

1. Surgical caps
2. Surgical scrub suits
3. Surgical masks
4. Plastic gloves
5. Film badges and/or pocket dosimeters
6. Respirators (if necessary)
7. Adhesive tape
8. Plastic sheets and bags
9. Surgical gowns
10. Shoe covers
11. Geiger counters
12. Filter paper for smears
13. Signs and labels stating "radioactive material" and/or "radiation area"
14. Cotton-tipped applicators
15. Large barrels, marked with radiation signs, in which all contaminated liquids and clothing may be placed.

HANDLING OF CONTAMINATED CASUALTIES

Priority for treatment or decontamination generally will be determined by the seriousness of non-radiation injury, the levels of skin or clothing contamination, and the possibility of radionuclides entering the body through contaminated wounds. In general, trauma is more serious than contamination and must be treated first if it is life-threatening. All bleeding must be stopped and other life-support procedures instituted prior to decontamination. Collect all urine for at least 24 hours in appropriately marked containers.

DETECTION OF CONTAMINATION OF WOUNDS

1. Survey wound areas with a Geiger-Mueller (G-M) Survey Meter. If the surrounding area is contaminated, the wound is considered to be contaminated.
2. Wipe separate sterile, moistened cotton-tipped applicators over the wound and area around the wound prior to treatment. Place the applicators in individual envelopes which list the patient's name, date, time and location wiped.

DETECTION OF RADIONUCLIDE CONTAMINATION OF THE SKIN

1. Make a G-M survey quickly over the entire body with the clothes on.
2. If radioactivity is found, remove the clothing and re-survey.
3. If contamination is found or suspected, wipe a cotton-tipped applicator over the area and place it in a labeled envelope for counting.
4. If contamination is found on the face, a sterile, moistened cotton-tipped applicator should be wiped gently about the anterior nares (not deep in the nose) and placed in a labeled envelope for counting.

DECONTAMINATION PROCEDURES

Gross Whole Body Contamination

1. Remove patient's clothing.
2. If areas of high levels of radioactivity are found,localize and mark.
3. Seal open wounds with plastic and/or waterproof adhesive tape to prevent contamination being washed into the wounds.
4. Shower or wash with warm water and soap, taking care that the contamination from high level areas is washed off rather than spread over the rest of the body. Do not abrade the skin. All contaminated water should be kept in appropriately marked containers.
5. As soon as body contamination is lowered, begin wound treatment or, if no wounds are present, shift to localized skin decontamination.

Localized Skin Contamination

1. Mark the area of skin contamination.
2. Begin treatment of area of highest contamination.
3. **Do not injure or abrade skin.**
4. Do not spread contamination to other areas of the skin.
5. Wash with water and soap using a gauze pad. Save all contaminated water in specially marked containers.
6. Put gauze pads used for decontamination in a plastic bag and label.
7. Re-survey, using a G-M counter and record results.
8. Repeat steps 5 and 7 as necessary.

Contaminated Wounds

1. Encourage bleeding when possible.
2. Irrigate with copious amounts of saline. Save contaminated saline in specially marked containers.
3. **Do not wash skin contamination into the wound.**
4. Re-survey wound at periodic intervals using a G-M counter or wipe with sterile cotton-tipped applicator. Record findings.
5. Decontaminate skin around the wound.
6. When wound and surrounding skin are decontaminated, seal area with plastic or waterproof adhesive tape.

Eye Contamination

1. The only treatment for cornea contamination is copious irrigation.
2. Sample irrigation fluid at frequent intervals, label samples and save for counting. Save irrigation fluids in specially marked containers.
3. After decontamination, treat irrigation-induced conjunctivitis.

Contamination of Body Entrance Cavities

1. Survey and record results.
2. Make sure the cavity is actually contaminated and not the surrounding area.
3. Evaluate and decontaminate surrounding area.
4. Irrigate with copious amounts of water or normal saline. Save all contaminated fluids in appropriately marked containers.
5. Gently swab with moistened cotton-tipped applicator.
6. Re-survey.
7. If necessary, and not irritating, use cotton-tipped applicator moistened with soap.

Contaminated Hairy Areas

1. Survey and record results.
2. Wrap or position patient to avoid spread of contamination.
3. Wash with soap and save all contaminated fluids in appropriately marked barrels.
4. Dry with clean uncontaminated towel. Do not shave hair. If necessary hair may be cut, but do not injure skin.
5. Re-survey and record.
6. If contamination persists, repeat above steps.

Disposition of Patient

Once the patient has been treated for both trauma and contamination, transfer can be made to an appropriate area within the hospital. Collect all urine for 24 hours. Repeat monitoring of all contaminated areas.

NOTIFICATION OF APPROPRIATE AUTHORITIES

1. Notify Nuclear Regulatory Commission.
2. Notify your state's department of radiological control and health services.
3. Do not notify the newspapers or make any public statements relative to the situation until they have been cleared by the Radiation Safety Officer, Administration and Public Relations.

WASTE DISPOSAL

1. Collect contaminated water and put in plastic containers for sampling and appropriate disposal.
2. Put contaminated disposable supplies in plastic bags for disposal.
3. Keep contaminated equipment in the controlled area until decontaminated.

PERSONNEL DISPOSITION

1. All persons entering the control area will be dressed and equipped as the situation warrants.
2. Survey all persons when they leave the control area.
3. Personnel contamination will be handled in the same manner as described above.
4. When dressed in their street clothes, all personnel will again report to a control point for a final recorded survey.
5. Request all personnel to collect successive urine samples for analysis of radioactivity, if the situation warrants.
6. The ambulance and ambulance personnel will remain at the hospital until surveyed and declared free of contamination.

LIMITS OF PERSONNEL EXTERNAL RADIATION EXPOSURE

1. All practical efforts will be made to keep personnel exposure to less than one (1) rem.**
2. The allowance of greater personnel exposures will be at the discretion of the health physicist.

** Higher levels can be chosen for life-threatening situations.

EMERGENCY TELEPHONE NUMBERS

Health Physicist ______________________________
Radiation Safety Officer ______________________________
Hospital Administrator ______________________________
Nursing Supervisor ______________________________

Nuclear Medicine Physician ______________________________
Nuclear Medicine Technologist ______________________________
Public Relations ______________________________
Others ______________________________

* Adapted from the Medical Radiation Emergency Plan of the Penn State Hershey Medical Center, Hershey, PA.

Courses in Handling Radiation Emergencies

Radiation Emergency Assistance Center/Training Site (REAC/TS)

The Oak Ridge Institute for Science and Education's (ORISE's) Radiation Emergency Assistance Center/Training Site (REAC/TS) offers several courses in handling radiation emergencies. Courses fill up quickly. The **course brochure/registration form** is available as a PDF file (611 KB). A new form must be submitted annually. Registration for these courses is accepted by mail or through our **online registration form**. Dates, course descriptions, and respective incidental fees can also be found below.

Accreditation

The Oak Ridge Institute for Science and Education (ORISE) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. ORISE takes responsibility for the content, quality, and scientific integrity of this ACCME activity. Respective courses are also accredited by the American College of Emergency Physicians and the American Academy of Health Physics.

REAC/TS offers the following courses:

Handling Radiation Emergencies by Emergency Department Personnel

Oct. 19-22, 2004	Jan. 25-28, 2005	March 8-11, 2005	April 5-8, 2005
May 3-6, 2005	Sept. 13-16, 2005		
Fee: $75	Maximum enrollment: 20		

This 3 1/2-day course is intended for physicians, nurses, and physicians' assistants who may be called upon to provide emergency medical service in the event of a radiation emergency. The course emphasizes the practical aspects of handling a contaminated victim by discussing the fundamentals of radiation, how to detect and measure it, how to prevent the spread of contamination, how to reduce the radiation dose to the victim and attending personnel, and the role of the medical/health physicist in caring for contaminated victims. Additional topics include nuclear terrorism, mass casualty management, and combined injuries in radiation emergencies. Demonstrations, laboratory exercises, and a drill will complement the didactic presentations.

Health Physics in Radiation Emergencies

Feb. 14-18, 2005	June 6-10, 2005	Aug. 22-26, 2005
Fee: $90	Maximum enrollment: 20	

This 4 1/2-day course is intended for health physicists and radiation protection technologists who may be called upon to respond to emergencies involving radioactive materials and injury to personnel. The major topics covered are radiological emergency procedures and the role of the health physicist in a medical environment. Demonstrations, laboratory exercises, group problem solving sessions and a drill will complement the didactic presentations.

Medical Planning and Care in Radiation Emergencies

March 14-18, 2005	Sept. 19-23, 2005
Fee: $90	Maximum enrollment: 26

This 4 1/2-day course, designed primarily for physicians and physicians' assistants, presents an advanced level of information on the diagnosis and treatment of acute local and total body radiation exposure, internal and external contamination, combined injuries, and multi-casualty incidents involving ionizing radiation. It is recommended that participants have a basic understanding of radiation sciences before attending this course. Demonstrations, laboratory exercises, and group problem solving sessions will complement the didactic presentations.

CDC's Roles in the Event of a Radiological Terrorist Event

August 10, 2004

Because of recent terrorist events, people may be concerned about the possibility of a terrorist attack involving radioactive materials. People may wonder what the Centers for Disease Control and Prevention (CDC) would do to protect people's health if such an event were to occur. CDC has prepared this fact sheet to help people understand the roles and responsibilities of CDC during such an incident.

Lead Federal Agencies

In the event of a radiological accident or terrorist attack, the agency that is responsible for the site of the incident also has responsibility for responding to the emergency and protecting the people, property, and environment around the area. For example, if the incident occurs on property owned by the federal government, such as a military base, research facility, or nuclear facility, then the federal government takes responsibility. In areas that are not controlled by the federal government, the state and local governments have the responsibility to respond to the emergency and protect people, property, and the environment.

Regardless of whether the state, local, or federal government is responsible for responding to the emergency, a federal agency would be sent to the terrorist incident site and would act as the Lead Federal Agency (LFA). This agency would work with the state and local government and might be the Nuclear Regulatory Commission (NRC), the Federal Bureau of Investigation (FBI), or another agency depending on what type of incident occurred (accidental or intentional release of radioactive materials) and where it occurred (nuclear power plant versus a spilled radioactive material in an urban or suburban area). The LFA would implement the Federal Radiological Emergency Response Plan (FRERP); within this plan, the Department of Health and Human Services (HHS) has the major role in protecting people's health through:

- Monitoring, assessing, and following up on people's health
- Ensuring the safety of workers involved in and responding to the incident
- Ensuring that the food supply is safe
- Providing medical and public health advice

CDC's Roles

As part of HHS, CDC would be the chief public health entity to respond to a radiological incident, whether accidental or intentional. As the chief public health entity, CDC's specific roles and responsibilities would include:

- Assessing the health of people affected by the incident
- Assessing the medical effects of radiological exposures on people in the community, emergency responders and other workers, and high-risk populations (such as children, pregnant women, and those with immune deficiencies)
- Advising state and local health departments on how to protect people, animals, and food and water supplies from contamination by radioactive materials

- Providing technical assistance and consultation to state and local health departments on medical treatment, follow-up, and decontamination of victims exposed to radioactive materials
- Establishing and maintaining a registry of people exposed to or contaminated by radioactive materials

CDC's Partners

To carry out its roles, CDC would work with many other agencies to ensure that people's health is protected. These agencies may include:

- State and Local Health Departments
- Department of Defense (DoD)
- Department of Energy (DOE)
- Department of Transportation (DOT)
- HHS
  - Food and Drug Administration (FDA)
  - Agency for Toxic Substances and Disease Registry (ATSDR)
  - Office of Emergency Response (OER)
  - Health Resources and Services Administration (HRSA)
  - Substance Abuse and Mental Health Services Administration (SAMHSA)
- Environmental Protection Agency (EPA)
- FBI
- Federal Emergency Management Agency (FEMA)
- NRC
- Department of Agriculture (USDA)

CDC's Actions

In the hours and days following a radiological incident, CDC would assist and advise the LFA and the state and local health departments on recommendations that the community would need to:

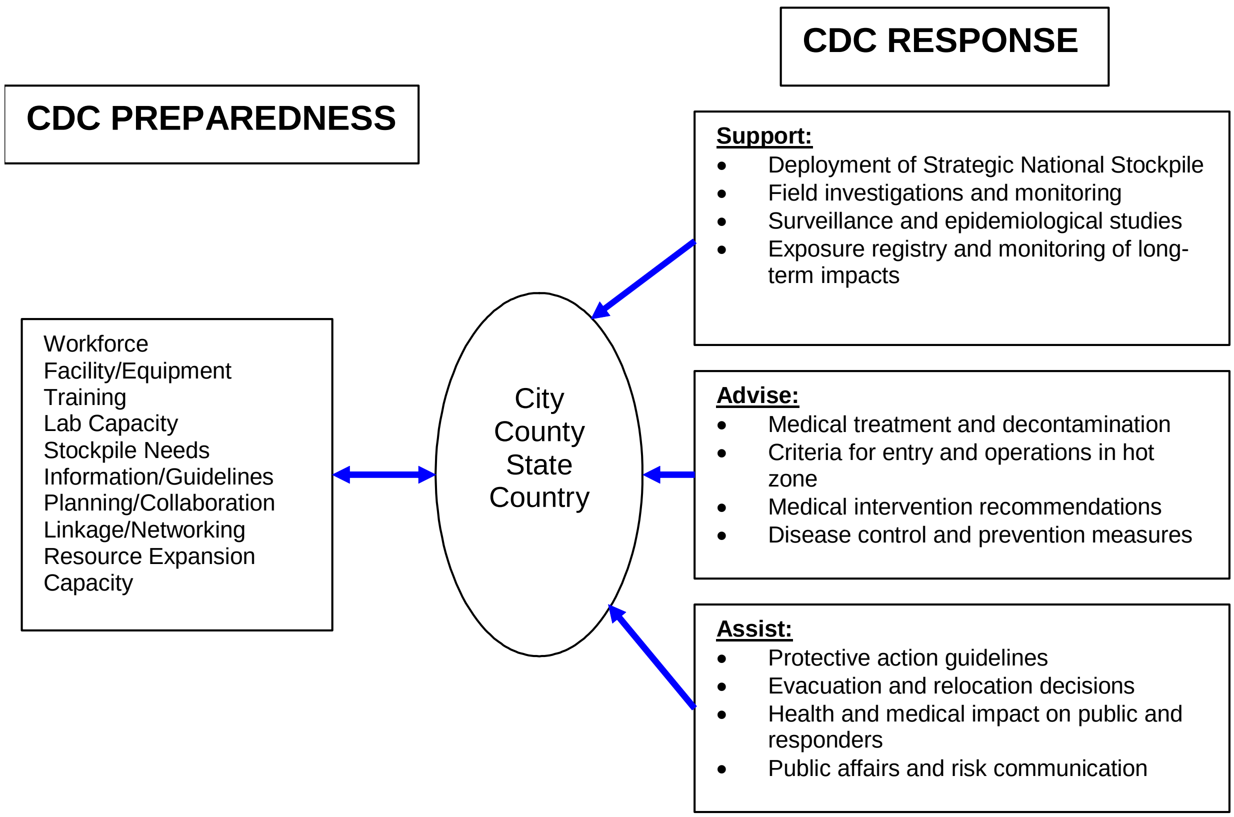
- Protect people from radioactive fallout
- Protect people from radioactive contamination in the area
- Safely use food and water supplies from the area
- Assess and explain the dangers in the area of the incident

If necessary, CDC would also deploy the Strategic National Stockpile, a federal store of drugs and medical supplies set aside for emergency situations.
In addition, CDC would give workers in the area information on:

- The amount of time they can safely work in an area contaminated with radioactive materials
- Equipment needed to protect themselves from radiation and radioactive materials
- Types of respiratory devices needed to work in the contaminated area
- How to use radiation monitoring devices

Radiation Exposure Registry

Following an incident involving radioactive materials, CDC would work with ATSDR to establish an exposure registry. The purpose of this registry would be to monitor people's exposure to radiation and perform dose reconstructions to determine the exact amount of radiation to which people were exposed. This registry would help CDC determine the necessary long-term medical follow-up for those who were affected by the incident.



For more information, see CDC's websites at www.cdc.gov, www.bt.cdc.gov, and www.cdc.gov/nceh/radiation/response.htm.

The Centers for Disease Control and Prevention (CDC) protects people's health and safety by preventing and controlling diseases and injuries; enhances health decisions by providing credible information on critical health issues; and promotes healthy living through strong partnerships with local, national, and international organizations.

FAQs

Frequently Asked Questions about a Radiation Emergency

What Is Radiation?

- Radiation is a form of energy that is present all around us.
- Different types of radiation exist, some of which have more energy than others.
- Amounts of radiation released into the environment are measured in units called **curies**. However, the dose of radiation that a person receives is measured in units called **rem**.

For more information on radiation measurement, see the CDC fact sheet "Radiation Measurement" at www.bt.cdc.gov/radiation/measurement.asp.

For more information about radiation check the following Web sites:

- U.S. Environmental Protection Agency: "Radiation" (www.epa.gov/radiation)
- Radiation Emergency Assistance Center/Training Site of Oak Ridge Associated Universities: "Radiation Accident Management" (www.orau.gov/reacts/injury.htm)

How Can Exposure Occur?

- People are exposed to small amounts of radiation every day, both from naturally occurring sources (such as elements in the soil or cosmic rays from the sun), and man-made sources. Man-made sources include some electronic equipment (such as microwave ovens and television sets), medical sources (such as x-rays, certain diagnostic tests, and treatments), and from nuclear weapons testing.
- The amount of radiation from natural or man-made sources to which people are exposed is usually small; a radiation emergency (such as a nuclear power plant accident or a terrorist event) could expose people to small or large doses of radiation, depending on the situation.
- Scientists estimate that the average person in the United States receives a dose of about one-third of a rem per year. About 80% of human exposure comes from natural sources and the remaining 20% comes from man-made radiation sources – mainly medical x-rays.
- Contamination refers to particles of radioactive material that are deposited anywhere that they are not supposed to be, such as on an object or on a person's skin.
- Internal contamination refers to radioactive material that is taken into the body through breathing, eating, or drinking.
- Exposure occurs when radiation energy penetrates the body. For example, when a person has an x-ray, he or she is exposed to radiation.

For more information on contamination and exposure, see the CDC fact sheet "Radioactive Contamination and Radiation Exposure" at www.bt.cdc.gov/radiation/contamination.asp.

What Happens When People Are Exposed to Radiation?

- Radiation can affect the body in a number of ways, and the adverse health effects of exposure may not be apparent for many years.

- These adverse health effects can range from mild effects, such as skin reddening, to serious effects such as cancer and death, depending on the amount of radiation absorbed by the body (the dose), the type of radiation, the route of exposure, and the length of time a person was exposed.
- Exposure to very large doses of radiation may cause death within a few days or months.
- Exposure to lower doses of radiation may lead to an increased risk of developing cancer or other adverse health effects later in life.

For more information about health effects from radiation exposure, check the following Web sites:

- U.S. Environmental Protection Agency: "Radiation" (www.epa.gov/radiation)
- Radiation Emergency Assistance Center/Training Site of Oak Ridge Associated Universities: "Radiation Accident Management" (www.orau.gov/reacts/injury.htm)

What Types of Terrorist Events Might Involve Radiation?

- Possible terrorist events could involve introducing radioactive material into the food or water supply, using explosives (like dynamite) to scatter radioactive materials (called a "dirty bomb" [see www.bt.cdc.gov/radiation/dirtybombs.asp]), bombing or destroying a nuclear facility, or exploding a small nuclear device.
- Although introducing radioactive material into the food or water supply most likely would cause great concern or fear, it probably would not cause much contamination or increase the danger of adverse health effects.
- Although a dirty bomb could cause serious injuries from the explosion, it most likely would not have enough radioactive material in a form that would cause serious radiation sickness among large numbers of people. However, people who were exposed to radiation scattered by the bomb could have a greater risk of developing cancer later in life, depending on their dose.
- A meltdown or explosion at a nuclear facility could cause a large amount of radioactive material to be released. People at the facility would probably be contaminated with radioactive material and possibly be injured if there was an explosion. Those people who received a large dose might develop acute radiation syndrome (see www.bt.cdc.gov/radiation/ars.asp). People in the surrounding area could be exposed or contaminated.
- Clearly, an exploded nuclear device could result in a lot of property damage. People would be killed or injured from the blast and might be contaminated by radioactive material. Many people could have symptoms of acute radiation syndrome. After a nuclear explosion, radioactive fallout would extend over a large region far from the point of impact, potentially increasing people's risk of developing cancer over time.

For more information about radiation terrorist events, see the CDC Radiation Emergencies website at www.bt.cdc.gov/radiation or check with the following organizations:

- Oak Ridge Radiation Emergency Assistance/Training Site (www.orau.gov/reacts)
- U.S. National Response Team (www.nrt.org)
- U.S. Department of Energy (www.energy.gov)
- Nuclear Regulatory Commission (www.nrc.gov)
- U.S. Environmental Protection Agency (www.epa.gov)

What Preparations Can I Make for a Radiation Emergency?

- Your community should have a plan in place in case of a radiation emergency. Check with community leaders to learn more about the plan and possible evacuation routes.
- Check with your child's school, the nursing home of a family member, and your employer to see what their plans are for dealing with a radiation emergency.
- Develop your own family emergency plan so that every family member knows what to do.

- At home, put together an emergency kit that would be appropriate for any emergency. The kit should include the following items:
  - A flashlight with extra batteries
  - A portable radio with extra batteries
  - Bottled water
  - Canned and packaged food
  - A hand-operated can opener
  - A first-aid kit and essential prescription medications
  - Personal items such as paper towels, garbage bags, and toilet paper

For more information about preparing for a radiation emergency event, check the following Web sites:

- Federal Emergency Management Agency (www.fema.gov)
- American Red Cross: "Terrorism – Preparing for the Unexpected" (www.redcross.org/services/disaster/0,1082,0_589_,00.html)
- U.S. Environmental Protection Agency's Office of Emergency Management (www.epa.gov/swercepp)

How Can I Protect Myself During a Radiation Emergency?

- After a release of radioactive materials, local authorities will monitor the levels of radiation and determine what protective actions to take.
- The most appropriate action will depend on the situation. Tune to the local emergency response network or news station for information and instructions during any emergency.
- If a radiation emergency involves the release of large amounts of radioactive materials, you may be advised to "shelter in place," which means to stay in your home or office; or you may be advised to move to another location.
- If you are advised to shelter in place, you should do the following:
  - Close and lock all doors and windows.
  - Turn off fans, air conditioners, and forced-air heating units that bring in fresh air from the outside. Only use units to recirculate air that is already in the building.
  - Close fireplace dampers.
  - If possible, bring pets inside.
  - Move to an inner room or basement.
  - Keep your radio tuned to the emergency response network or local news to find out what else you need to do.
- If you are advised to evacuate, follow the directions that your local officials provide. Leave the area as quickly and orderly as possible. In addition –
  - Take a flashlight, portable radio, batteries, first-aid kit, supply of sealed food and water, hand-operated can opener, essential medicines, and cash and credit cards.
  - Take pets only if you are using your own vehicle and going to a place you know will accept animals. Emergency vehicles and shelters usually will not accept animals.

For more information about evacuation, see the CDC fact sheet "Facts About Evacuation During a Radiation Emergency" at www.bt.cdc.gov/radiation/evacuation.asp.

For more information about sheltering, see the CDC fact sheet "Sheltering in Place During a Radiation Emergency" at www.bt.cdc.gov/radiation/shelter.asp or the American Red Cross fact sheet "Shelter-in-Place" at www.redcross.org/services/disaster/beprepared/shelterinplace.pdf.

For more information about emergency response, check the following Web sites:

- Federal Emergency Management Agency (www.fema.gov)

- American Red Cross": "Disaster Services" (www.redcross.org/services/disaster/0,1082,0_500_,00.html)
- U.S. Environmental Protection Agency's Office of Emergency Management (www.epa.gov/swercepp)

Should I Take Potassium Iodide During a Radiation Emergency?

- Potassium iodide (KI) should only be taken in a radiation emergency that involves the release of radioactive iodine, such as an accident at a nuclear power plant or the explosion of a nuclear bomb. A "dirty bomb" most likely will not contain radioactive iodine.
- A person who is internally contaminated with radioactive iodine may experience thyroid disease later in life. The thyroid gland will absorb radioactive iodine and may develop cancer or abnormal growths later on. KI will saturate the thyroid gland with iodine, decreasing the amount of harmful radioactive iodine that can be absorbed.
- KI only protects the thyroid gland and does not provide protection from any other radiation exposure.
- Some people are allergic to iodine and should not take KI. Check with your doctor about any concerns you have about potassium iodide.

For more information about KI, see the CDC fact sheet "Potassium Iodide (KI)" at www.bt.cdc.gov/radiation/ki.asp or check the following Web sites:

- U.S. Food and Drug Administration: "Frequently Asked Questions on Potassium Iodide (KI)" (www.fda.gov/cder/drugprepare/KI_Q&A.htm)
- U.S. Food and Drug Administration: "Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies" (www.fda.gov/cder/guidance/4825fnl.htm)

FREQUENTLY ASKED QUESTIONS (FAQS)

Dirty Bombs

People have expressed concern about dirty bombs and what they should do to protect themselves if a dirty bomb incident occurs. Because your health and safety are our highest priorities, the health experts at the Centers for Disease Control and Prevention (CDC) have prepared the following list of frequently asked questions and answers about dirty bombs.

What is a dirty bomb?

A dirty bomb is a mix of explosives, such as dynamite, with radioactive powder or pellets. When the dynamite or other explosives are set off, the blast carries radioactive material into the surrounding area.

A dirty bomb is *not* the same as an atomic bomb
An atomic bomb, like those bombs dropped on Hiroshima and Nagasaki, involves the splitting of atoms and a huge release of energy that produces the atomic mushroom cloud.

A dirty bomb works completely differently and *cannot create an atomic blast*. Instead, a dirty bomb uses dynamite or other explosives to scatter radioactive dust, smoke, or other material in order to cause radioactive contamination.

What are the main dangers of a dirty bomb?

The main danger from a dirty bomb is from the explosion, which can cause serious injuries and property damage. The radioactive materials used in a dirty bomb would probably not create enough radiation exposure to cause immediate serious illness, except to those people who are very close to the blast site. However, the radioactive dust and smoke spread farther away could be dangerous to health if it is inhaled. Because people cannot see, smell, feel, or taste radiation, you should take immediate steps to protect yourself and your loved ones.

What immediate actions should I take to protect myself?

These simple steps—recommended by doctors and radiation experts—will help protect you and your loved ones. The steps you should take depend on where you are located when the incident occurs: outside, inside, or in a vehicle.

If you are outside and close to the incident

- Cover your nose and mouth with a cloth to reduce the risk of breathing in radioactive dust or smoke.
- Don’t touch objects thrown off by an explosion—they might be radioactive.
- Quickly go into a building where the walls and windows have not been broken. This area will shield you from radiation that might be outside.
- Once you are inside, take off your outer layer of clothing and seal it in a plastic bag if available. Put the cloth you used to cover your mouth in the bag, too. Removing outer clothes may get rid of up to 90% of radioactive dust.
- Put the plastic bag where others will not touch it and keep it until authorities tell you what to do with it.

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- Shower or wash with soap and water. Be sure to wash your hair. Washing will remove any remaining dust.
- Tune to the local radio or television news for more instructions.

If you are inside and close to the incident

- If the walls and windows of the building are not broken, stay in the building and do not leave.
- To keep radioactive dust or powder from getting inside, shut all windows, outside doors, and fireplace dampers. Turn off fans and heating and air-conditioning systems that bring in air from the outside. It is not necessary to put duct tape or plastic around doors or windows.
- If the walls and windows of the building are broken, go to an interior room and do not leave. If the building has been heavily damaged, quickly go into a building where the walls and windows have not been broken. If you must go outside, be sure to cover your nose and mouth with a cloth. Once you are inside, take off your outer layer of clothing and seal it in a plastic bag if available. Store the bag where others will not touch it.
- Shower or wash with soap and water, removing any remaining dust. Be sure to wash your hair.
- Tune to local radio or television news for more instructions.

- **If you are in a car when the incident happens**
  - Close the windows and turn off the air conditioner, heater, and vents.
  - Cover your nose and mouth with a cloth to avoid breathing radioactive dust or smoke.
  - If you are close to your home, office, or a public building, go there immediately and go inside quickly.
  - If you cannot get to your home or another building safely, pull over to the side of the road and stop in the safest place possible. If it is a hot or sunny day, try to stop under a bridge or in a shady spot.
  - Turn off the engine and listen to the radio for instructions.
  - Stay in the car until you are told it is safe to get back on the road.

What should I do about my children and family?

- If your children or family are with you, stay together. Take the same actions to protect your whole family.
- If your children or family are in another home or building, they should stay there until you are told it is safe to travel.
- Schools have emergency plans and shelters. If your children are at school, they should stay there until it is safe to travel. Do not go to the school until public officials say it is safe to travel.

How do I protect my pets?

- If you have pets outside, bring them inside if it can be done safely.
- Wash your pets with soap and water to remove any radioactive dust.

Should I take potassium iodide?

- Potassium iodide, also called KI, only protects a person's thyroid gland from exposure to radioactive iodine. KI will not protect a person from other radioactive materials or protect other parts of the body from exposure to radiation.
- Since there is no way to know at the time of the explosion whether radioactive iodine was used in the explosive device, taking KI would probably not be beneficial. Also, KI can be dangerous to some people.

Will food and water supplies be safe?

- Food and water supplies most likely will remain safe. However, any unpackaged food or water that was out in the open and close to the incident may have radioactive dust on it. Therefore, do not consume water or food that was out in the open.
- The food inside of cans and other sealed containers will be safe to eat. Wash the outside of the container before opening it.
- Authorities will monitor food and water quality for safety and keep the public informed.

How do I know if I've been exposed to radiation or contaminated by radioactive materials?

- People cannot see, smell, feel, or taste radiation; so you may not know whether you have been exposed. Police or firefighters will quickly check for radiation by using special equipment to determine how much radiation is present and whether it poses any danger in your area.
- Low levels of radiation exposure (like those expected from a dirty bomb situation) do not cause any symptoms. Higher levels of radiation exposure may produce symptoms, such as nausea, vomiting, diarrhea, and swelling and redness of the skin.
- If you develop any of these symptoms, you should contact your doctor, hospital, or other sites recommended by authorities.

Where do I go for more information?

- For more information about dirty bombs, radiation, and health, contact:
  - The Conference of Radiation Control Program Directors (CRCPD) http://www.crcpd.org (502) 227-4543
  - The U.S. Environmental Protection Agency (EPA) http://www.epa.gov/radiation/rert/
  - The Nuclear Regulatory Commission (NRC) http://www.nrc.gov/ (301) 415-8200
  - The Federal Emergency Management Agency (FEMA) http://www.fema.gov/ (202) 646-4600
  - The Radiation Emergency Assistance Center/Training Site (REAC/TS) http://www.orau.gov/reacts/ (865) 576-3131
  - The U.S. National Response Team (NRT) http://www.nrt.org/
  - The U.S. Department of Energy (DOE) http://www.energy.gov/engine/content.do 1-800-dial-DOE

FACT SHEET

Radioactive Contamination and Radiation Exposure

Radioactive contamination and radiation exposure could occur if radioactive materials are released into the environment as the result of an accident, an event in nature, or an act of terrorism. Such a release could expose people and contaminate their surroundings and personal property.

What Radioactive Contamination Is

Radioactive contamination occurs when radioactive material is deposited on or in an object or a person. Radioactive materials released into the environment can cause air, water, surfaces, soil, plants, buildings, people, or animals to become contaminated. A contaminated person has radioactive materials on or inside their body.

What External Contamination Is

External contamination occurs when radioactive material, in the form of dust, powder, or liquid, comes into contact with a person's skin, hair, or clothing. In other words, the contact is external to a person's body. People who are externally contaminated can become internally contaminated if radioactive material gets into their bodies.

What Internal Contamination Is

Internal contamination occurs when people swallow or breathe in radioactive materials, or when radioactive materials enter the body through an open wound or are absorbed through the skin. Some types of radioactive materials stay in the body and are deposited in different body organs. Other types are eliminated from the body in blood, sweat, urine, and feces.

What Radiation Exposure Is

Radioactive materials give off a form of energy that travels in waves or particles. This energy is called radiation. When a person is exposed to radiation, the energy penetrates the body. For example, when a person has an x-ray, he or she is exposed to radiation.

How Contamination Differs From Exposure

A person exposed to radiation is not necessarily contaminated with radioactive material. A person who has been exposed to radiation has had radioactive waves or particles penetrate the body, like having an x-ray. For a person to be contaminated, radioactive material must be on or inside of his or her body. A contaminated person is exposed to radiation released by the radioactive material on or inside the body. An uncontaminated person can be exposed by being too close to radioactive material or a contaminated person, place, or thing.

How Exposure or Contamination Can Happen

Radioactive materials could be released into the environment in the following ways:

- A nuclear power plant accident
- An atomic bomb explosion
- An accidental release from a medical or industrial device
- Nuclear weapons testing
- An intentional release of radioactive material as an act of terrorism

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How Radioactive Contamination Is Spread

People who are externally contaminated with radioactive material can contaminate other people or surfaces that they touch. For example, people who have radioactive dust on their clothing may spread the radioactive dust when they sit in chairs or hug other people.

People who are internally contaminated can expose people near them to radiation from the radioactive material inside their bodies. The body fluids (blood, sweat, urine) of an internally contaminated person can contain radioactive materials. Coming in contact with these body fluids can result in contamination and/or exposure.

How Your Home Could Become Contaminated

People who are externally contaminated can spread the contamination by touching surfaces, sitting in a chair, or even walking through a house. Contaminants can easily fall from clothing and contaminate other surfaces. Homes can also become contaminated with radioactive materials in body fluids from internally contaminated people. Making sure that others do not come in contact with body fluids from a contaminated person will help prevent contamination of other people in the household.

How You Can Limit Contamination

Since radiation cannot be seen, smelled, felt, or tasted, people at the site of an incident will not know whether radioactive materials were involved. You can take the following steps to limit your contamination.

1. **Get out of the immediate area quickly.** Go inside the nearest safe building or to an area to which you are directed by law enforcement or health officials.

2. **Remove the outer layer of your clothing.** If radioactive material is on your clothes, getting it away from you will reduce the external contamination and decrease the risk of internal contamination. It will also reduce the length of time that you are exposed to radiation.

3. If possible, **place the clothing in a plastic bag or leave it in an out-of-the-way area**, such as the corner of a room. Keep people away from it to reduce their exposure to radiation. Keep cuts and abrasions covered when handling contaminated items to avoid getting radioactive material in them.

4. **Wash all of the exposed parts of your body** using lots of soap and lukewarm water to remove contamination. This process is called **decontamination**. Try to avoid spreading contamination to parts of the body that may not be contaminated, such as areas that were clothed.

5. After authorities determine that **internal contamination may have occurred**, you may be able to take medication to reduce the radioactive material in your body.

For more information, visit www.bt.cdc.gov/radiation,
or call CDC at 800-CDC-INFO (English and Spanish) or 888-232-6348 (TTY).

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FACT SHEET

Acute Radiation Syndrome: A Fact Sheet for Physicians

Acute Radiation Syndrome (ARS) (sometimes known as radiation toxicity or radiation sickness) is an acute illness caused by irradiation of the entire body (or most of the body) by a high dose of penetrating radiation in a very short period of time (usually a matter of minutes). The major cause of this syndrome is depletion of immature parenchymal stem cells in specific tissues. Examples of people who suffered from ARS are the survivors of the Hiroshima and Nagasaki atomic bombs, the firefighters that first responded after the Chernobyl Nuclear Power Plant event in 1986, and some unintentional exposures to sterilization irradiators.

The required conditions for Acute Radiation Syndrome (ARS) are:

- **The radiation dose must be large** (i.e., greater than 0.7 Gray (Gy)[1,2] or 70 rads).
  - Mild symptoms may be observed with doses as low as 0.3 Gy or 30 rads.
- **The dose usually must be external** (i.e., the source of radiation is outside of the patient's body).
  - Radioactive materials deposited inside the body have produced some ARS effects only in extremely rare cases.
- **The radiation must be penetrating** (i.e., able to reach the internal organs).
  - High energy X-rays, gamma rays, and neutrons are penetrating radiations.
- **The entire body** (or a significant portion of it) must have received the dose.[3]
  - Most radiation injuries are local, frequently involving the hands, and these local injuries seldom cause classical signs of ARS.
- **The dose must have been delivered in a short time** (usually a matter of minutes).
  - Fractionated doses are often used in radiation therapy. These large total doses are delivered in small daily amounts over a period of time. Fractionated doses are less effective at inducing ARS than a single dose of the same magnitude.

The three classic ARS Syndromes are:

- **Bone marrow syndrome** (sometimes referred to as hematopoietic syndrome)**:** the full syndrome will usually occur with a dose greater than approximately 0.7 Gy (70 rads) although mild symptoms may occur as low as 0.3 Gy or 30 rads.[4]
  - The survival rate of patients with this syndrome decreases with increasing dose. The primary cause of death is the destruction of the bone marrow, resulting in infection and hemorrhage.
- **Gastrointestinal (GI) syndrome:** the full syndrome will usually occur with a dose greater than approximately 10 Gy (1000 rads) although some symptoms may occur as low as 6 Gy or 600 rads.

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[1] The Gray (Gy) is a unit of absorbed dose and reflects an amount of energy deposited into a mass of tissue (1 Gy = 100 rads). In this document, the referenced absorbed dose is that dose inside the patient's body (i.e., the dose that is normally measured with personal dosimeters).

[2] The referenced absorbed dose levels in this document are assumed to be from beta, gamma, or x radiation. Neutron or proton radiation produces many of the health effects described herein at lower absorbed dose levels.

[3] The dose may not be uniform, but a large portion of the body must have received more than 0.7 Gy (70 rads).

[4] Note: although the dose ranges provided in this document apply to most healthy adult members of the public, a great deal of variability of radiosensitivity among individuals exists, depending upon the age and condition of health of the individual at the time of exposure. Children and infants are especially sensitive.

  - Survival is extremely unlikely with this syndrome. Destructive and irreparable changes in the GI tract and bone marrow usually cause infection, dehydration, and electrolyte imbalance. Death usually occurs within 2 weeks.
- **Cardiovascular (CV) / Central Nervous System (CNS) syndrome:** the full syndrome will usually occur with a dose greater than approximately 50 Gy (5000 rads) although some symptoms may occur as low as 20 Gy or 2000 rads.
  - Death occurs within 3 days. Death likely is due to collapse of the circulatory system as well as increased pressure in the confining cranial vault as the result of increased fluid content caused by edema, vasculitis, and meningitis.

The four stages of ARS are:

- **Prodromal stage (N-V-D stage):** The classic symptoms for this stage are nausea, vomiting, as well as anorexia and possibly diarrhea (depending on dose), which occur from minutes to days following exposure. The symptoms may last (episodically) for minutes up to several days.
- **Latent stage:** In this stage, the patient looks and feels generally healthy for a few hours or even up to a few weeks.
- **Manifest illness stage:** In this stage, the symptoms depend on the specific syndrome (see Table 1) and last from hours up to several months.
- **Recovery or death:** Most patients who do not recover will die within several months of exposure. The recovery process lasts from several weeks up to two years.

These stages are described in more detail in Table 1.

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Table 1. Acute Radiation Syndromes

Syndrome	Dose*	Prodromal Stage	Latent Stage	Manifest Illness Stage	Recovery
Hematopoietic (Bone marrow)	> 0.7 Gy (> 70 rads) *(mild symptoms may occur as low as 0.3 Gy or 30 rads)*	• Symptoms are anorexia, nausea and vomiting. • Onset occurs 1 hour to 2 days after exposure. • Stage lasts for minutes to days.	• Stem cells in bone marrow are dying, although patient may appear and feel well. • Stage lasts 1 to 6 weeks.	• Symptoms are anorexia, fever, and malaise. • Drop in all blood cell counts occurs for several weeks. • Primary cause of death is infection and hemorrhage. • Survival decreases with increasing dose. • Most deaths occur within a few months after exposure.	• In most cases, bone marrow cells will begin to repopulate the marrow. • There should be full recovery for a large percentage of individuals from a few weeks up to two years after exposure • Death may occur in some individuals at 1.2 Gy (120 rads). • The $LD_{50/60}$† is about 2.5 to 5 Gy (250 to 500 rads).
Gastrointestinal (GI)	> 10 Gy (> 1000 rads) *(some symptoms may occur as low as 6 Gy or 600 rads)*	• Symptoms are anorexia, severe nausea, vomiting, cramps, and diarrhea. • Onset occurs within a few hours after exposure. • Stage lasts about 2 days.	• Stem cells in bone marrow and cells lining GI tract are dying, although patient may appear and feel well. • Stage lasts less than 1 week.	• Symptoms are malaise, anorexia, severe diarrhea, fever, dehydration, and electrolyte imbalance. • Death is due to infection, dehydration, and electrolyte imbalance. • Death occurs within 2 weeks of exposure.	• The LD_{100}‡ is about 10 Gy (1000 rads).
Cardiovascular (CV)/ Central Nervous System (CNS)	> 50 Gy (5000 rads) *(some symptoms may occur as low as 20 Gy or 2000 rads)*	• Symptoms are extreme nervousness and confusion; severe nausea, vomiting, and watery diarrhea; loss of consciousness; and burning sensations of the skin. • Onset occurs within minutes of exposure. • Stage lasts for minutes to hours.	• Patient may return to partial functionality. • Stage may last for hours but often is less.	• Symptoms are return of watery diarrhea, convulsions, and coma. • Onset occurs 5 to 6 hours after exposure. • Death occurs within 3 days of exposure.	• No recovery is expected.

* The absorbed doses quoted here are "gamma equivalent" values. Neutrons or protons generally produce the same effects as gamma, beta, or X-rays but at lower doses. If the patient has been exposed to neutrons or protons, consult radiation experts on how to interpret the dose.
† The $LD_{50/60}$ is the dose necessary to kill 50% of the exposed population in 60 days.
‡ The LD_{100} is the dose necessary to kill 100% of the exposed population.

Cutaneous Radiation Syndrome (CRS)

The concept of cutaneous radiation syndrome (CRS) was introduced in recent years to describe the complex pathological syndrome that results from acute radiation exposure to the skin.

ARS usually will be accompanied by some skin damage. It is also possible to receive a damaging dose to the skin without symptoms of ARS, especially with acute exposures to beta radiation or X-rays. Sometimes this occurs when radioactive materials contaminate a patient's skin or clothes.

When the basal cell layer of the skin is damaged by radiation, inflammation, erythema, and dry or moist desquamation can occur. Also, hair follicles may be damaged, causing epilation. Within a few hours after irradiation, a transient and inconsistent erythema (associated with itching) can occur. Then, a latent phase may occur and last from a few days up to several weeks, when intense reddening, blistering, and ulceration of the irradiated site are visible.

In most cases, healing occurs by regenerative means; however, very large skin doses can cause permanent hair loss, damaged sebaceous and sweat glands, atrophy, fibrosis, decreased or increased skin pigmentation, and ulceration or necrosis of the exposed tissue.

Patient Management

Triage: If radiation exposure is suspected:

- Secure ABCs (airway, breathing, circulation) and physiologic monitoring (blood pressure, blood gases, electrolyte and urine output) as appropriate.
- Treat major trauma, burns, and respiratory injury if evident.
- In addition to the blood samples required to address the trauma, obtain blood samples for CBC (complete blood count), with attention to lymphocyte count, and HLA (human leukocyte antigen) typing prior to any initial transfusion and at periodic intervals following transfusion.
- Treat contamination as needed.
- If exposure occurred within 8 to 12 hours, repeat CBC, with attention to lymphocyte count, 2 or 3 more times (approximately every 2 to 3 hours) to assess lymphocyte depletion.

Diagnosis

The diagnosis of ARS can be difficult to make because ARS causes no unique disease. Also, depending on the dose, the prodromal stage may not occur for hours or days after exposure, or the patient may already be in the latent stage by the time they receive treatment, in which case the patient may appear and feel well when first assessed.

If a patient received more than 0.05 Gy (5 rads) and three or four CBCs are taken within 8 to 12 hours of the exposure, a quick estimate of the dose can be made (see Ricks, et. al. for details). If these initial blood counts are not taken, the dose can still be estimated by using CBC results over the first few days. It would be best to have radiation dosimetrists conduct the dose assessment, if possible.

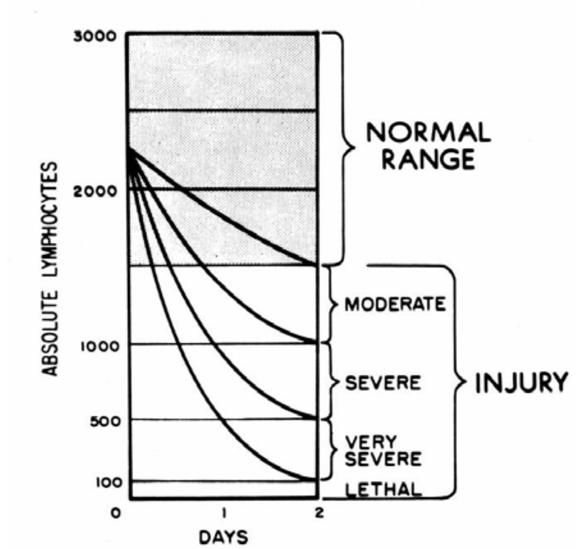
If a patient is known to have been or suspected of having been exposed to a large radiation dose, draw blood for CBC analysis with special attention to the lymphocyte count, every 2 to 3 hours during the first 8 hours after exposure (and every 4 to 6 hours for the next 2 days). Observe the patient during this time for symptoms and consult with radiation experts before ruling out ARS.

If no radiation exposure is initially suspected, you may consider ARS in the differential diagnosis if a history exists of nausea and vomiting that is unexplained by other causes. Other indications are bleeding, epilation, or white blood count (WBC) and platelet counts abnormally low a few days or weeks after unexplained nausea and vomiting. Again, consider CBC and chromosome analysis and consultation with radiation experts to confirm diagnosis.

Initial Treatment and Diagnostic Evaluation

Treat vomiting[5] and repeat CBC analysis with special attention to the lymphocyte count every 2 to 3 hours for the first 8 to 12 hours after exposure (and every 4 to 6 hours for the following 2 or 3 days). Sequential changes in absolute lymphocyte counts over time are demonstrated below in the Andrews Lymphocyte Nomogram (see Figure 1). Precisely record all clinical symptoms, particularly nausea, vomiting, diarrhea, and itching, reddening or blistering of the skin. Be sure to include time of onset.

Figure 1: Andrews Lymphocyte Nomogram



From Andrews GA, Auxier JA, Lushbaugh CC. *The Importance of Dosimetry to the Medical Management of Persons Exposed to High Levels of Radiation.* In *Personal Dosimetry for Radiation Accidents*. Vienna: International Atomic Energy Agency; 1965.

Note and record areas of erythema. If possible, take color photographs of suspected radiation skin damage. Consider tissue, blood typing, and initiating viral prophylaxis. Promptly consult with radiation, hematology, and radiotherapy experts about dosimetry, prognosis, and treatment options. Call the Radiation Emergency Assistance Center/Training Site (REAC/TS) at (865) 576-3131 (M-F, 8 am to 4:30 am EST) or (865) 576-1005 (after hours) to record the incident in the Radiation Accident Registry System.

After consultation, begin the following treatment (as indicated):

- supportive care in a clean environment (if available, the use of a burn unit may be quite effective)
- prevention and treatment of infections
- stimulation of hematopoiesis by use of growth factors
- stem cell transfusions or platelet transfusions (if platelet count is too low)
- psychological support
- careful observation for erythema (document locations), hair loss, skin injury, mucositis, parotitis, weight loss, or fever
- confirmation of initial dose estimate using chromosome aberration cytogenetic bioassay when possible. Although resource intensive, this is the best method of dose assessment following acute exposures.
- consultation with experts in radiation accident management

5 Collect vomitus in the first few days for later analysis.

For More Help

Technical assistance can be obtained from the Radiation Emergency Assistance Center/Training Site (REAC/TS) at (865) 576-3131 (M-F, 8 am to 4:30 pm EST) or (865) 576-1005 (after hours), or on their web site at www.orau.gov/reacts, and the Medical Radiobiology Advisory Team (MRAT) at (301) 295-0316.

Also, more information can be obtained from the CDC Health Alert Network at www.bt.cdc.gov or by calling (800) 311-3435.

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FACT SHEET

Prenatal Radiation Exposure: A Fact Sheet for Physicians

Most radiation exposure events will not expose the fetus to levels likely to cause health effects. This is true for radiation exposure from most diagnostic medical exams as well as from occupational radiation exposures that fall within regulatory limits. However, instances may arise where an expectant mother and her physician should have some concern. This brochure provides physicians with background information about prenatal radiation exposure as an aid in counseling these patients.

Because the human embryo or fetus is protected in the uterus, a radiation dose to a fetus tends to be lower than the dose to its mother for most radiation exposure events. However, the human embryo and fetus are particularly sensitive to ionizing radiation, and the health consequences of exposure can be severe, even at radiation doses too low to immediately affect the mother. Such consequences can include growth retardation, malformations, impaired brain function, and cancer.

Estimating the Radiation Dose to the Embryo or Fetus

Because fetal sensitivity to radiation exposure depends largely on the radiation dose to the fetus, the dose needs to be estimated before potential health effects can be assessed.

Estimating the radiation dose to the fetus requires consideration of all sources external and internal to the mother's body. For this document, the fetal radiation dose from sources external to the mother's body can be estimated by determining the dose to the mother's abdomen. Estimating the dose from sources internal to the mother's body is more complex.

If a pregnant woman ingests or inhales a radioactive substance that subsequently is absorbed in her bloodstream (or enters her bloodstream through a contaminated wound), the radioactive substance may pass through the placenta to the fetus. Even though for some substances the placenta acts as a barrier to the fetal blood, most substances that reach the mother's blood can be detected in the fetus' blood, with concentrations that depend on the specific substance and the stage of fetal development. A few substances needed for fetal growth and development (such as iodine) can concentrate more in the fetus than in corresponding maternal tissue. In addition, radioactive substances that may concentrate in the maternal tissues surrounding the uterus including the mother's urinary bladder can irradiate the fetus. For substances that can localize in specific organs and tissues in the fetus, such as iodine-131 or iodine-123 in the thyroid, iron-59 in the liver, gallium-67 in the spleen, and strontium-90 and yttrium-90 in the skeleton, consideration of the dose to specific fetal organs may be prudent.

Physicians should consult with experts in radiation dosimetry about fetal dose estimation.

Hospital medical physicists and health physicists are good resources for expertise in radiation dose estimation. The National Council on Radiation Protection and Measurements (NCRP) Report No. 128, "Radionuclide Exposure of the Embryo/Fetus," provides detailed information for assessing fetal doses from internal uptakes. Fetal dose estimations from medical exposures to pregnant women can be found in "Publication 84: Pregnancy and Medical Radiation" from the International Commission on Radiological Protection (ICRP). In addition, the Conference of Radiation Control Program Directors, Inc. (CRCPD) maintains a list of state Radiation Control/Radiation Protection contact information at www.crcpd.org/map/map.asp and the Health Physics Society (HPS) maintains of list of active certified

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Health Physicists at www.hps1.org/aahp/members/members.htm. Physicians should contact these organizations for assistance in estimating fetal radiation dose.

Once the fetal radiation dose is estimated, the potential health effects can be assessed. The possible effects associated with prenatal radiation exposure include immediate effects (such as fetal death or malformations) or increased risk for cancer later in life.

Potential Health Effects of Prenatal Radiation Exposure (Other Than Cancer)

The potential noncancer health risks of concern are summarized in Table 1. This table is intended only to help physicians advise pregnant women who may have been exposed to radiation, not as a definitive recommendation. The indicated doses and times post conception, or gestational age, are approximations.

Table 1: Potential Health Effects (Other Than Cancer) of Prenatal Radiation Exposure

Acute Radiation Dose* to the Embryo/Fetus	Time Post Conception				
	Blastogenesis (up to 2 wks)	Organogenesis (2–7 wks)	Fetogenesis		
			(8–15 wks)	(16–25 wks)	(26–38 wks)
< 0.05 Gy (5 rads)†	**Noncancer health effects NOT detectable**				
0.05–0.50 Gy (5–50 rads)	Incidence of failure to implant may increase slightly, but surviving embryos will probably have no significant (noncancer) health effects	• Incidence of major malformations may increase slightly • Growth retardation possible	• Growth retardation possible • Reduction in IQ possible (up to 15 points, depending on dose) • Incidence of severe mental retardation up to 20%, depending on dose	**Noncancer health effects unlikely**	
> 0.50 Gy (50 rads) *The expectant mother may be experiencing acute radiation syndrome in this range, depending on her whole-body dose.*	Incidence of failure to implant will likely be large‡, depending on dose, but surviving embryos will probably have no significant (noncancer) health effects	• Incidence of miscarriage may increase, depending on dose • Substantial risk of major malformations such as neurological and motor deficiencies • Growth retardation likely	• Incidence of miscarriage probably will increase, depending on dose • Growth retardation likely • Reduction in IQ possible (> 15 points, depending on dose) • Incidence of severe mental retardation > 20%, depending on dose • Incidence of major malformations will probably increase	• Incidence of miscarriage may increase, depending on dose • Growth retardation possible, depending on dose • Reduction in IQ possible, depending on dose • Severe mental retardation possible, depending on dose • Incidence of major malformations may increase	Incidence of miscarriage and neonatal death will probably increase depending on dose§

Note: This table is intended only as a guide. The indicated doses and times post conception are approximations.

*Acute dose: dose delivered in a short time (usually minutes). Fractionated or chronic doses: doses delivered over time. For fractionated or chronic doses the health effects to the fetus may differ from what is depicted here.

†Both the gray (Gy) and the rad are units of absorbed dose and reflect the amount of energy deposited into a mass of tissue (1 Gy = 100 rads). In this document, the absorbed dose is that dose received by the entire fetus (whole-body fetal dose). The referenced absorbed dose levels in this document are assumed to be from beta, gamma, or x-radiation. Neutron or proton radiation produces many of the health effects described herein at lower absorbed dose levels.

‡A fetal dose of 1 Gy (100 rads) will likely kill 50% of the embryos. The dose necessary to kill 100% of human embryos or fetuses before 18 weeks' gestation is about 5 Gy (500 rads).

§For adults, the LD50/60 (the dose necessary to kill 50% of the exposed population in 60 days) is about 3-5 Gy (300-500 rads) and the LD100 (the dose necessary to kill 100% of the exposed population) is around 10 Gy (1000 rads).

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Gestational age and radiation dose are important determinants of potential noncancer health effects. The following points are of particular note:

- **Before about 2 weeks gestation (i.e., the time after conception), the health effect of concern from an exposure of > 0.1 gray (Gy) or 10 rads[1] is the death of the embryo. If the embryo survives, however, radiation-induced noncancer health effects are unlikely, no matter what the radiation dose.** Because the embryo is made up of only a few cells, damage to one cell, the progenitor of many other cells, can cause the death of the embryo, and the blastocyst will fail to implant in the uterus. Embryos that survive, however, will exhibit few congenital abnormalities.

- **In all stages of gestation, radiation-induced noncancer health effects are not detectable for fetal doses below about 0.05 Gy (5 rads).** Most researchers agree that a dose of < 0.05 Gy (5 rads) represents no measurable noncancer risk to the embryo or fetus at any stage of gestation. Research on rodents suggests a small risk may exist for malformations, as well as effects on the central nervous system in the 0.05–0.10 Gy (5–10 rads) range for some stages of gestation. However, a practical threshold for congenital effects in the human embryo or fetus is most likely between 0.10–0.20 Gy (10–20 rads).

- **From about 16 weeks' gestation to birth, radiation-induced noncancer health effects are unlikely below about 0.50 Gy (50 rads).** Although some researchers suggest that a small possibility exists for impaired brain function above 0.10 Gy (10 rads) in the 16- to 25-week stage of gestation, most researchers agree that after about 16 weeks' gestation, the threshold for congenital effects in the human embryo or fetus is approximately 0.50–0.70 Gy (50–70 rads).

The normal rate of failure of a blastocyst to implant in the uterine wall is high, perhaps 30%–50%. After the embryo implants there, however, the miscarriage rate decreases to about 15% for the rest of the pregnancy, and the cells begin differentiating into various stem cells that eventually form all of the organs in the body.

Ionizing radiation can impair the developmental events that occur at exposure. Also, atomic bomb survivor data show a permanent retardation of physical growth with increasing dose, particularly above 1 Gy (100 rads). This retardation of growth is most pronounced when the exposure occurs in the first 13 weeks of gestation. Atomic bomb survivor data suggest about a 3%–4% reduction of height at age 18 when the dose is greater than 1 Gy (100 rads).

Radiation may significantly affect brain development among persons exposed at 8–15 weeks' gestation. Atomic bomb survivor data indicate that, in this stage, the average IQ loss is approximately 25–31 points per Gy (per 100 rads) above 0.1 Gy (10 rads), and the risk for severe mental retardation[2] is approximately 40% per Gy (per 100 rads), above 0.1 Gy (10 rads).

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[1] Both the gray (Gy) and the rad are units of absorbed dose and reflect the amount of energy deposited into a mass of tissue (1 Gy = 100 rads). In this document, the absorbed dose is that dose received by the entire fetus (whole-body fetal dose). The referenced absorbed dose levels in this document are assumed to be from beta, gamma, or x-radiation. Neutron or proton radiation produces many of the health effects described herein at lower absorbed dose levels.

[2] For studies of the atomic bomb victims, severe mental retardation was related not to IQ, but to clinical observation: "unable to perform simple calculations, to make simple conversation, to care for himself or herself, or if he or she was completely unmanageable or had been institutionalized" (Schull, 1995). This corresponds to an IQ less than 50 (0.4% prevalence in the unexposed population).

The central nervous system is less sensitive in the 16- to 25-week stage of gestation. However, the same effects seen in the 8- to 15-week stage also may occur at this time at higher doses. In the 16- to 25-week stage the average IQ loss is approximately 13–21 points per Gy (per 100 rads) at doses above 0.7 Gy (70 rads), and the risk for severe mental retardation is approximately 9% per Gy (per 100 rads) above 0.7 Gy (70 rads). Also, if internal uptake of radioactive iodine occurs in this stage, the long-term health consequences to the thyroid of the offspring should be considered. The fetal thyroid is very active in this stage, and if the mother ingests or inhales radioactive iodine, it will concentrate in the fetal thyroid as well as in the mother's thyroid.

Beyond about 26 weeks, the fetus is less sensitive to the noncancer health effects of radiation exposure than in any other stage of gestation. However, at doses above 1 Gy (100 rads) the risks for miscarriage and neonatal death (i.e., infant death within 28 days after birth, including stillbirth) increases.

Potential Carcinogenic Effects of Prenatal Radiation Exposure

Cancer risk for a specific time of life (such as childhood) often is separately assessed from cancer risk over a person's entire life. The risk for **childhood cancer** from prenatal radiation exposure is shown in Table 2. For estimation purposes, the lifetime cancer incidence risk for exposure at age 10 years also is shown in Table 2.

Table 2: Estimated Risk for Cancer from Prenatal Radiation Exposure

Radiation Dose	Estimated Childhood Cancer Incidence*, †	Estimated Lifetime‡ Cancer Incidence§ (exposure at age 10)
No radiation exposure above background	0.3%	38%
0.00–0.05 Gy (0–5 rads)	0.3%–1%	38%–40%
0.05–0.50 Gy (5–50 rads)	1%–6%	40%–55%
> 0.50 Gy (50 rads)	> 6%	> 55%

* Data published by the International Commission on Radiation Protection.
† Childhood cancer mortality is roughly half of childhood cancer incidence.
‡ The **lifetime cancer** risks from prenatal radiation exposure are not yet known. The lifetime risk estimates given are for Japanese males exposed at age 10 years from models published by the United Nations Scientific Committee on the Effects of Atomic Radiation.
§ Lifetime cancer mortality is roughly one third of lifetime cancer incidence.

In addition,

Whether the carcinogenic effects for a given dose vary on the basis of gestation period has not been determined. At this time, the carcinogenic risks are assumed to be constant throughout the pregnancy. However, analysis of animal data suggest that while there is a strong sensitivity to carcinogenic effects in late fetal development, the stages of blastogenesis and organogenesis are not found to be susceptible.

The radiation risk for childhood cancer from prenatal radiation exposure has been estimated, but the lifetime cancer risk is not yet known. Studies are under way to determine the lifetime cancer risk from prenatal radiation exposure. However, early indications are that cancer risk from prenatal radiation exposure is similar to, or slightly higher than, cancer risk from exposure in childhood. Therefore, lifetime cancer risk from childhood radiation exposure can provide a good approximation of the prenatal risk.

Conclusion

Fetal sensitivity to radiation-induced health effects is highly dependent on fetal dose, and the mother's abdomen provides some protection from external sources of ionizing radiation. In addition, noncancer health effects depend on gestational age. This document should provide helpful information about the complex issue of prenatal radiation exposure to physicians counseling expectant mothers who may have been exposed to ionizing radiation.

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Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident

December 2003

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Summary

On September 11, 2001, U.S. symbols of economic growth and military prowess were attacked and thousands of innocent lives were lost. These tragic events exposed our nation's vulnerability to attack and heightened our awareness of potential threats. Further examination of the capabilities of foreign nations indicate that terrorist groups worldwide have access to information on the development of radiological weapons and the potential to acquire the raw materials necessary to build such weapons. The looming threat of attack has highlighted the vital role that public health agencies play in our nation's response to terrorist incidents. Such agencies are responsible for detecting what agent was used (chemical, biological,

Department of Homeland Security Working Group on Radiological Dispersal Device (RDD) Preparedness

Medical Preparedness and Response Sub-Group

5/1/03 Version

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MEDICAL GUIDELINES
IONIZING RADIATION AND TERRORIST INCIDENTS: IMPORTANT POINTS FOR THE PATIENT AND YOU

1. All patients should be medically stabilized from their traumatic injuries before radiation injuries are considered. Patients are then evaluated for either *external radiation exposure* or radioactive *contamination.*

2. An external radiation source with enough intensity and energy can cause tissue damage (e.g., skin burns or marrow depression). This exposure from a source outside the person does not make the person radioactive. Even such lethally exposed patients are no hazard to medical staff.

3. Nausea, vomiting, diarrhea and skin erythema within four hours may indicate very high (but treatable) external radiation exposures. Such patients will show obvious lymphopenia within 8-24 hours. Evaluate with serial CBC's. Primary systems involved will be skin, intestinal tract and bone marrow. Treatment is supportive with fluids, antibiotics, and transfusions stimulating factors. If there are early CNS findings or unexplained hypotension, survival is unlikely.

4. Radioactive material may have been deposited on or in the person (contamination). More than 90% of surface radioactive contamination is removed by removal of the clothing. Most remaining contamination will be on exposed skin and is effectively removed with soap, warm water, and a washcloth. Do not damage skin by scrubbing.

5. Protect yourself from radioactive contamination by observing standard precautions, including protective clothing, gloves, and a mask.

6. Radioactive contamination in wound or burns should be handled as if it were simple dirt. If an unknown metallic object is encountered, it should only be handled with instruments such as forceps and should be placed in a protected or shielded area.

7. In a terrorist incident, there may be continuing exposure of the public that is essential to evaluate. Initially suggest sheltering and a change of clothing or showering. Evacuation may be necessary. Administration of potassium iodine (KI) is only indicated when there has been release of radioiodine.

8. When there is any type of radiation incident many persons will want to know whether they have been exposed or are contaminated. Provisions need to be made to potentially deal with thousands of such persons.

9. Radiation doses to people are expressed in Gray (Gy) or Sieverts (Sv). The older units for these are rad and rem. 1 Gray = 100 rad and 1 Sv = 100 rem. An approximation of the relative hazard is given:

Dose	Relative Hazard
About 10 milligray or 10 millisievert (1 rad or rem) or less	No acute effects and only a very small chance of subsequent cancer.
About 0.1 gray or 0.1 sievert	No acute effects, subsequent additional risk of cancer about 0.5%
About 1 gray or 1 sievert	Nausea, vomiting possible, mild bone marrow depression subsequent risk of cancer 5%
Greater than 2 gray or sievert	Definite nausea, vomiting, medical evaluation and treatment required

The amount of radioactivity (contamination) is measured in units of Bequerels (Bq) (1 disintegration per second). Sometimes, it is expressed in counts per minute. Decontamination is usually stopped if the item is reduced to two times the background count rate or if repeated decontamination efforts are ineffective.

10. The principal of *time/distance/shielding* is key. Even in treatment of Chernobyl workers, does to the medical staff were about 10 milligray or 10 millisievert. Doses to first responders at the scene, however, can be much higher and appropriate dose rate meters must be available for evaluation. Radiation dose is reduced by reducing time spent in the radiation area (moderately effective), increasing distance from a radiation source (very effective) or using metal or concrete shielding (less practical).

MEDICAL GUIDELINES

RADIOLOGICAL PROTECTION FOR FIRST RESPONDERS AND FIRST CONTACT MEDICAL PERSONNEL

2/25/03 Version

Background

The following basic question should drive the actions and precautions of first responders to an RDD event:

- How badly injured are the victims?

RDD events are very unlikely to contaminate victims in a way that will be harmful to responders or caregivers. If a victim is acutely injured, responders should attend to those injuries immediately, regardless of the type or degree of personal protective equipment that is available. Normal barrier clothing and masks should be used if available, but care of patients with life-threatening injuries should not be delayed because first responders lack adequate personal protective equipment Contaminated personnel, equipment, and vehicles can be cleaned later, at little risk to human health or the integrity of the equipment.

In situations involving less-seriously injured victims, or with more time to prepare, greater discretion and attention to personal protective equipment is permissible and in fact recommended.

RDD events, by their nature, disperse radioactive material. There is a risk that finely-divided material may be ingested, inhaled, or absorbed through the skin, although contamination via the latter routes would be uncommon.

Improvised nuclear devices, producing a nuclear detonation, will spread much more radioactive material over a much wider area**.** The precautions that responders must take in this case, however, will be essentially the same.

Radiation is colorless, odorless, tasteless and invisible. The only way to determine whether radioactive material has been involved in an event is to perform *radiological surveys* with specialized equipment. Whenever a hazardous material release is suspected, the incident commander should inform responders of any special precautions that need to be taken.

The three main concerns for first responders to a radiologically contaminated site are, in this order:

- Care of patients with acute traumatic injuries
- Respiratory protection, and
- Skin (barrier) protection.

Respiratory Protection

PPE protection levels are classified A, B, and C, A being the greatest protection level, and C the least. For situations where airborne particulates are the chief concern, such as RDD events, Level C protection is generally sufficient.

There are several approaches to respiratory protection. Fit-tested full or half-mask cartridge-filtered respirators should be used when available. Powered-air purifying respirators (PAPRs) are also useful. Any respiratory protection that is designed to protect responders against chemical or biological agents will likely offer benefits in an RDD event. In fact, concerns for the presence of chemical contaminants at a terrorist event will drive the selection of respiratory protection as they may require a higher level of PPE.

One of the best approaches is also one of the simplest. Ordinary surgical facemasks provide good protection against inhaling particulates, and allow excellent air transfer for working at high breathing rates. If available, high-efficiency particulate air (HEPA) filter masks such as the common NIOSH "N-95" mask provide even better protection. These are standard issue for health care workers who work with patients with tuberculosis and other highly contagious diseases. These masks must be fit-tested to each individual by personnel trained in the OSHA-accepted methods. Under stressful conditions, however, they may cause breathing difficulties, due to their inherently reduced air transfer.

On must always consider other, greater hazards when selecting breathing protection. If authorities suspect that particulates such as anthrax or other such bacterial agents are present, an N-95 mask is required. Neither common surgical nor N-95 masks protect against gases and vapors, however. If chemical agents are suspected, level B or higher protection is required, for both the lungs and the skin. This means fitted, full-face respirators and chemical-resistant coveralls.

Skin Protection

Current weather conditions, as well as the environment at the event, will drive the selection of anti-contamination clothing. Normal barrier clothing and gloves give excellent personal protection against airborne particles. Disposable medical scrub suits, high-density polyethylene coveralls (e.g., Tyvek®), or other close-weave coveralls and hood should be used if they are available.

The choice of clothing will often be driven by other more immediate hazards, such as fire, heat, or chemicals. Protection for these hazards covers any additional threat that radioactive material could pose.

As stated above, transport of the severely injured to available acute care medical facilities should not be delayed due to suspected or confirmed radiological contamination on the patient. If a critically injured but contaminated patient must be transferred immediately, make preparations for limitation of contamination at the destination facility.

Handling of Bodies

Radioactive materials may contaminate the deceased. Appropriate radiation survey assistance can confirm or rule out such a situation. If a body is known or suspected to be contaminated, personnel engaged in handling of the body should be issued personal protective equipment. As stated above, it is important for responders and mortuary personnel to be aware of other, more acutely hazardous agents that may co-contaminate the remains in question. Appropriately higher levels of protection should be used as needed.

Radiation Dosimetry

Two types of devices may be used. The first type is a clip-on badge containing either film or other radiation-sensitive material (AKA a thermoluminescent dosimeter or TLD). The second type of device is a reusable electronic dosimeter, which can be read visually or by other reading devices. Some devices of this type also “chirp” like the traditional Geiger counter. Radiation protection personnel will distribute and explain how to use such devices.

Cost and Scope Implications

Estimated Cost:

Equipment	Cost per Piece
Surgical mask	$1.00 (less than half that in quantity)
Respirator mask, N-95	$4.00 to $5.00 (as little as $1.00 or less in quantity)
Respirator mask, full-face	$50.00 to $200.00
Surgical scrub suit, disposable	$3.00
Skin protective coverall, disposable	$4.00 to $8.00
Radiation dosimetry, single-use	$5.00 to $7.00 (much less in quantity)
Radiation dosimetry, repeat-use	$150 to$400

Scope of Responders to Receive Equipment

For both a radiological dispersion device and an improvised nuclear device, all responders could reasonably be protected with respiratory and skin protection. Radiation dosimetry will be used as available, but by a minimum of 100-300 of the first responders who work closest to the point of detonation of an RDD or the hypocenter of a nuclear explosion.

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MEDICAL GUIDELINES

EVACUATION, SHELTERING, AND OTHER PUBLIC HEALTH MEASURES TO REDUCE/AVERT RADIATION DOSE

2/25/03 Version

Introduction

Terrorist events involving RDDs or INDs may give rise to situations in which the radiation exposure continues after the initiating event. Minimizing additional exposure in such circumstances is critical. Actions or instructions provided to the public in order to accomplish this goal may be termed “interventions.” Table 1 gives examples of protective actions. In general, interventions are not justified to avert effective doses of 10 mSv or less, but are almost always justified if potential averted doses are 100 mSv or more.

Table 1 - Examples of Protective Actions (Interventions) for Averting Exposures Via Various Pathways

Route of exposure	Protective action
External irradiation from a source	Control of access, shielding
Radionuclides in air or on ground	Control of access, sheltering, evacuation
External contamination	Protective clothing, decontamination
Inhalation of radioiodine	Stable iodine administration
Ingestion of radionuclides	Restricting contaminated food and water supply, decreasing incorporation into food chain, decontamination

* Criteria and rationale for administration of stable potassium iodide are discussed in another section

There are three general principles that form the basis for making decisions on intervention. First, all possible efforts should be made to prevent serious deterministic health effects (such as bone marrow depression and skin burns). There is no specific dose level at which intervention should be undertaken although, at levels of dose that would cause serious deterministic effects, some kind of intervention would be almost mandatory. The second principle is that the intervention should be justified in the sense that the protective measure should do more good than harm. While this may seem obvious, inappropriate actions have been taken in accidental situations to reduce dose at an extremely high social and monetary cost.

The third principle is that the levels at which an intervention is introduced and at which it is later withdrawn should be optimized. After an intervention is applied (e.g., evacuation or sheltering of a population), there needs to be optimization of the action to determine the scale and duration. Costs and benefits of such actions will change over time. If people have been relocated and the radioactivity decays sufficiently, the persons may be allowed to go back home.

Guidance for Occupational Exposure in Emergencies

When it is clear that an accident has occurred, it may be necessary to knowingly allow individuals to be exposed to relatively high levels of radiation. This may be necessary to perform an urgent intervention or even to save lives. Values recommended for such circumstances are shown in Table 2.

Table 2 - Guidance for Emergency Occupational Exposure

Type of action	Organ	Level (mSv)
Lifesaving (ICRP)	Whole body *	May exceed 500 effective dose
	Skin	May exceed 5000 equivalent dose
(NCRP)	Whole body (or large part)	May approach or exceed 500
	Skin	5000 equivalent dose
(EPA) (Informed Volunteer)	Whole body	>250 No absolute upper limit
(EPA)	Whole body	250
Urgent (ICRP)	Whole body	500 or less effective dose
	Skin	5000 or less equivalent dose
(NCRP)	Whole body	Annual occupational limits up to 50 effective dose
Limit for protecting valuable property of large populations (EPA)	Whole body	50
Limit for emergency services except lifesaving or protecting valuable property (EPA)	Whole body	100

* Refers to Effective Dose.

An example of use of this table would be to answer the question "How much dose could first responders get in order to recover persons who would otherwise die?" The consensus is more than 250 mSv and probably not a lot more than 500 mSv whole body dose. The rationale for this is than in this dose range there would not be acute radiation sickness but there would be an increased cancer risk of about 1-4% for the responders. Responders should be informed of the risks and exposures voluntary. Allowing persons to get over 1000 mSv would likely result in mild acute radiation sickness of the responders and given the uncertainties in an accident may result in some responder fatalities.

Responders in such situations should have dose rate meters or alarms. General entry to an area is permitted if dose rates are less than 0.1 mGy or mSv/hr and if dose rates of 100mGy or 100mSv/ hr are encountered, responders should turn back for further advice.

RADIATION PHARMACEUTICAL COUNTERMEASURES

Other Pharmaceuticals

Drug Name	Class	Supplier(s)	Status	Intended Use	Treatment Method	Notes
Neulasta® (pegfilgrastim)	cytokine G-CSF	Amgen, Inc.	FDA-approved for treating cancer patients undergoing therapy causing bone marrow suppression, NOT approved for radiation emergencies	Treat **ARS** victims suffering from neutropenia (low WBC count)	delivered by injection, extended half-life in the body, alleviates the need for daily injections as required by Neupogen.	SNS preferred to stockpile Neupogen after careful evaluation of several factors.
Leukine® (Sargramostim)	cytokine GM-CSF	Berlex Labs			Injection IV. Recommended dosage for treating radiation victims not published yet.	Drug very similar in action to Neupogen.
Ethyol® Amifostine WR-2721	broad spectrum cytoprotective agent; free radical scavenger	MedImmune, Inc.	FDA-approved for limited application in cancer therapy, NOT approved for radiation emergencies	general radioprotection, first-responders, public	Although this drug is approved for use in protecting normal tissues during head and neck cancer therapy and may be useful in preventing secondary malignancies, its <u>usefulness in radiation emergencies is questionable</u> - Toxic at doses high enough to offer general radioprotection. Low doses may lower risk of carcinogenesis.	
PHOSPHONOL™ WR-3689	broad spectrum cytoprotective agent; free radical scavenger	Hollis-Eden Pharmaceuticals	Under development		Not approved for any indication. Under development. Drug is similar to Ethyol (amifostine). See the note above.	
NEUMUNE™ HE2100 androstenediol	steroid	Hollis-Eden Pharmaceuticals	Under development; advanced trails in primates	Treat **ARS** victims suffering from neutropenia (low WBC count) and thrombocytopenia (low platelet count)	Still under development. Some advantages appear to be: 1) promotes regeneration of more than one cell type, 2) relatively less expensive to produce , 3) can be given outpatient, 4) suitable for mass administration after nuclear emergency.	
Homspera™ substance P	immunomodulator	ImmuneRegen Biosciences	Not approved	Treat **ARS**	No published results.	
Vitamin E	vitamin	multiple	Not approved for radiation emergencies	general radioprotection, first-responders, public	Experimental results with mice showing better survival rate from lethal gamma radiation. SC administration more efficacious tham oral. its <u>usefulness in radiation emergencies remains to be determined</u>.	
Nutritional supplements	variable supplements	Numerous suppliers e.g., Humanetics Corporation	Not approved for radiation emergencies	general radioprotection, first-responders, public	The company recently signed agreement with the Uniformed Services University of the Health Sciences to develop and test such products for use in radiation emergencies. <u>Usefulness in radiation emergencies remains to be determined.</u>	

Countermeasures for Internal Contamination
(see NCRP 65 for more info)
The FDA-approved countermeasures are highlighted.

	Radioelement	**Countermeasure**
Am	Americium	Ca/Zn DTPA
Bk	Berkelium	Ca/Zn DTPA
Cf	Californium	Ca/Zn DTPA
Cs	Cesium	Prussian blue
Co	Cobalt	Penecillamine
Cm	Curium	Ca/Zn DTPA
Au	Gold	Dimercaprol; penicillamine
I	Iodine	KI
P	Phosphorous	Na/K phosphates
Pu	Plutonium	Ca/Zn DTPA
Po	Polonium	Dimercaprol
Ra	Radium	magnesium sulfate; alginates
Sr	Strontium	Aluminum/Mg phosphates; alginates
H	Tritium	diuretics
U	Uranium	sodium bicarbonate
Y	Yttrium	DTPA

For **ARS** Victims	antibiotics; antiemetics; analgesics; cytokines

RADIATION PHARMACEUTICAL COUNTERMEASURES

Radiation Drugs in the Strategic National Stockpile (SNS)

Drug Name	Class	Supplier(s)	Status	Intended Use	Treatment Method	Notes
Potassium Iodide[a] **(KI)** IOSAT™ ThyroSafe™ (65 mg) Thyro-Block™ Thyroshield™ (solution)	Iodine blocker	Anbex, Inc. Recip US, Inc. (Sweden) Medpointe Pharm HLC Fleming & Company	FDA-approved	Prevent uptake of radioactive **iodine** by thyroid gland	Tablets or solution (for children). One dose per day of anticipated exposure. best taken immediately before or at time of exposure. Ineffective several hours after exposure.	Potassium iodate (KIO3) is found on the market. It can be as efficacious as KI and is used in Europe. However, KIO3 is NOT FDA-approved.
Prussian blue Ferric ferrocyanide (Radiogardase®)	decorporation agent	Heyl (Germany)	FDA-approved	Treat internal contamination - **cesium** or **thallium**	Capsules - can be swallowed or mixed in liquid for children; 3-4 times daily dose for up to 150 days, depending on intake	On average, reduces biological half-life of cesium by one-third; stool and urine will be contaminated
Ca-DTPA, Zn-DTPA (diethylenetriamine-pentaacetate)	chelator	Hamlen (Germany) Akorn, Inc. (US distributor)	FDA-approved	Treat internal contamination - **plutonium**, **americium**, and **curium**.	Intravenous delivery. Inhaler available. Most effective w/in 24 hours post exposure, but still effective weeks after. single dose may be sufficient. Daily treatment for extended period if necessary.	SNS current supply purchased before FDA approval has to be given under IND. Oral tablet in development but not yet available. May also be effective for **californium** and **berkelium**, but is not FDA-approved for these. **DO NOT** use to treat uranium or neptunium contamination.
Neupogen® (Filgrastim) G-CSF	cytokine G-CSF	Amgen, Inc.	IND? EUA	Treat **ARS** victims suffering from neutropenia (low WBC count)	Daily injection, IM or IV, for 2 weeks. SNS considered variety of factors and prefered this over Neulasta®	Drug is FDA-approved for treating cancer patients undergoing therapy causing bone marrow suppression

[a] Not all KI brand names are included in the Strategic National Stockpile. However, KI brand names listed here are all FDA-approved for use in radiation emergencies.

Medications and Mechanisms of Decorporation.
(Modified from Safety Series 47, IAEA)

Radionuclide	Medication	Applications In: Ingestion/Inhalation	Applications In: Wound	Principle of Action
Iodine	KI	130 mg stat, followed by 130 mg q.d. x 7 if indicated	Same	Blocking
Rare earths Plutonium Transplutonics Yttrium	DTPA	1 gm Ca-DTPA in 500 ml 5-percent D/W IV over 60 min; or 1 gm (4ml) in 6 ml 5-percent D/W slow IV injection (1min)	Same	Chelation
Polonium Mercury Arsenic Bismuth Gold	BAL	One ampule (300 mg) IM q4 hrs. for 3 days–(first test for sensitivity with 1/4 amp.)	Same	Promotes excretion
Uranium	Bicarbonate	<u>Oral dosage:</u> *Adults:* Initially, 4 g PO then 1-2 g every 4 hours. Titrate dosage based on urinary pH. *Children:* 1-10 mEq/kg/day (84-840 mg/kg/day) PO, given in divided doses every 4-6 hours. Parental dosage:Titrate dosage based on urinary pH. Slow IV infusion of Sodium Bicarbonate	Same	Alkalinization of urine; reduces chance of ATN
Cesium Rubidium Thallium	Prussian Blue [Ferrihexacyano-Ferrate (II)]	<u>Initial dosage</u>: 1 gm PO t.i.d. , may be increase according to excretion rate	Same	Mobilization from organs and tissues–reduction and absorption
Radium	Ca-gluconate	May be tried; 20-percent Ca-gluconate 10 ml IV qd or b.i.d.	Same	Displacement
Strontium	Ammonium chloride	3 gm t.i.d. PO	Same	Demineralizing agent
Tritium	Water	Have patient drink 6–12 liters of water per day	Same	Isotopic dilution
Strontium Radium	$BaSo_4$ (Barium Sulfate)	100 gm $BaSo_4$ in 250 ml of water	Same	Reduces absorption
Calcium Barium	Sodium alginate	10 gm in a large glass of water	Same	Inhibits absorption
Copper Polonium Lead Mercury Gold	D-penicillamine	1 gm IV q.d. or 0.9 gm PO q4–6 hrs.	Same	Chelation

ORAU-224. <u>Hospital Emergency Management of Radiation Accidents</u>. February 1984.

International Atomic Energy Agency and
World Health Organization

HOW TO RECOGNIZE AND INITIALLY RESPOND TO AN ACCIDENTAL RADIATION INJURY

Since the discovery of ionizing radiation, knowledge of its detrimental effects has accumulated. Despite considerable development in the techniques of radiation safety, accidents may happen which might injure people.

Radiation sources are widely used in medicine, industry, agriculture and research. They might be lost, stolen, or otherwise out of proper control and this can lead to injuries to persons who came into contact with them.

Radiation accidents are rare. The statistics show that between 1944 and 1999 in 405 accidents worldwide, approximately 3000 persons were injured, with 120 fatalities (including the 28 Chernobyl victims). During the last few years the number of accidents and incidents involving radiation sources has increased. Often the victims of such occurrences are unaware that they may have been exposed to radiation. The medical consequences of these situations might first be observed by general practitioners (GPs), dermatologists, haematologists, specialists in infectious diseases and other medical doctors, but diagnosis may not be immediately obvious. Lack of knowledge about the consequences of exposure to radiation is one of the main reasons why many accidental injuries are not recognized early enough for the most effective treatment. Health authorities and medical personnel therefore need to be prepared for such an eventuality.

This leaflet is intended to inform physicians — mainly GPs — and medical students on *how to recognize a possible radiation injury*. It is important to note that **radiation injury has no special signs and symptoms**. However, the combination of some of them may be typical of radiation injury.

What are the types of radiation exposure that might arise from an accident?

The exposure can be
- external to the body, in which case it may be to the whole body or limited to larger or smaller parts of the body, or
- internal due to contamination with radioactive materials, if ingested, inhaled, or deposited in wounds.

Exposure can be acute, protracted or fractionated. It can occur alone, or be combined with other injury, such as trauma, thermal burn, etc.

Recognizing radiation injuries by their clinical manifestations

Following a high-level accidental exposure to radiation, injuries evolve over time in distinct phases. The length and time of the occurrence of the phases depend on the dose. Low doses do not produce observable effects.

A typical course following **a whole body exposure** to a source of penetrating radiation involves an initial prodromal phase with symptoms such as nausea, vomiting, fatigue and possibly fever and diarrhoea, followed by a latent period of varying lengths. A period of illness follows, characterized by infection, bleeding and gastrointestinal symptoms. Problems in this period are due to deficiencies of cells of the haematopoietic system, and, with higher doses, to loss of cells lining the gastrointestinal tract.

A **local exposure**, depending on dose, can produce signs and symptoms in the exposed area such as erythema, oedema, dry and wet desquamation, blistering, pain, necrosis, gangrene or epilation. Local skin injuries evolve slowly over time — usually weeks to months — may become very painful and are difficult to treat by usual methods.

Partial body exposures result in a combination of varying symptoms as mentioned above, the type and severity of which depend on the dose to and volume of the exposed part of the body. Additional symptoms may be related to location of the tissues and organs involved.
There are usually no early symptoms associated with internal contamination unless the intake has been very high, which is extremely rare. If this has occurred, it will normally be obvious to the person concerned. Therefore, the focus of this leaflet is on external exposure resulting from radiation sources.

What are the main questions to ask the patients (when taking detailed anamnesis of a suspected radiation exposure)?

a) Did you find or come into physical contact with an unknown metallic object? If yes, when, where and how?
b) Did you see a sign like this  (eg. on its package)?
c) Were there similar symptoms among family members and colleagues at the same time?
d) Do you know how you received this injury?

What should the physician do if radiation injury is suspected?

- If the patient has a conventional injury or illness, save life and treat as normally required. Note that radiation does not produce life threatening early symptoms.
- Be aware that a radiation injured person does not present a health risk to the doctor.
- Do not touch any unfamiliar object in the patient's possession and move staff and patients to another room until the nature of the object has been determined by a radiation protection specialist.
- If contamination is suspected, avoid spread of material by using isolation procedures. Contact a radiation authority or radiation protection service for monitoring.
- Do a prompt complete blood count, repeated in 4 to 6 hours within a day. Look for a drop in the absolute lymphocyte count if exposure was recent. If the initial white blood cell and platelet counts are at the same time abnormally low, consider the possibility of an exposure of 3 to 4 weeks earlier. Additional daily blood counts will be needed.

Photo 1a. Early erythema in the frontal and antelateral right side of the chest 5 days after the exposure to an iridium-192 source (185 GBq, 5 Ci) mounted in a pen-size source holder for industrial radiography which was placed to the pocket of the worker's overall and kept there for about two hours.

Photo 1b. Early erythema 11 days after exposure.

- Notify health authority and radiation protection service if radiation injury is diagnosed or suspected.

Differential diagnosis of radiation injury

Consider radiation injury in a differential diagnosis if the patient presents with:

- A description of circumstances that might have led to a radiation exposure (eg. work with scrap metal).
- Nausea and vomiting, especially if accompanied by erythema, fatigue, diarrhoea or other symptoms not explained by other causes, such as intestinal infections, food poisoning and/or allergy.
- Skin lesions without knowledge of a chemical or thermal burn, or insect bite, or history of skin disease or allergy, but with desquamation and epilation in the exposed area further to erythema having occurred 2 to 4 weeks previously.
- Epilation or bleeding problems (such as petechia, gingival or nose bleedings) with a history of nausea and vomiting 2 to 4 weeks previously.

Photo 1c. Desquamation and skin necrosis 21 days after exposure. Note: the white areas correspond to silver ointment.

Photo 1d. Tense painful bulla of the left palm on day 20 evolving from erythema with early blistering which had appeared on day 10 after the initial contact for a few minutes with the iridium-192 source.

Some recommendations on your preparedness

- Have available in advance the telephone numbers of the health authorities and radiation protection service (and keep them up-to-date).
- Rely on professional information from the national health authority and radiation protection service and assist in the implementation of their recommendations.

Further readings

IAEA-WHO: Diagnosis and Treatment of Radiation Injuries. Safety Report Series, No. 2, IAEA, Vienna, 1998.

IAEA-WHO: Planning the Medical Response to Radiological Accidents. Safety Report Series, No. 4, IAEA, Vienna, 1998.

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Photo 2a. An ulcer in subacute stage and five ulcers following self-healing with depigmentation caused by being unawarely exposed 4-8 months earlier to the same164 GBq (4.4 Ci) cesium-137 source (placed in a pocket of a trench coat used as a blanket).

Photo 2b. Deep infected ulcer on the upper medial part of right thigh six months after being unawarely exposed to a 164 GBq (4.4 Ci) cesium-137 source.

UC Davis Emergency Dose Limits and Contamination Considerations for Radiological Emergency Response to a Radiation Casualty Incident*

In the case of a Radiation Casualty Incident, the following limits will be observed by the UC Davis to preserve lifesaving capabilities while minimizing the risk to staff and the disruption of our facilities.

1. Dose limits for staff performing emergency procedures will be increased from 0.1 to 45 rem. This will allow for an additional 5 rem for normal activities and a maximum allowable dose of 50 rem total effective dose equivalent for the calendar year. Dose limits for the skin will also be increased to 500 rem shallow dose equivalent for the calendar year. Staff will use the radiation protection principles of time, distance and shielding to maintain exposures As Low As Reasonably Achievable (ALARA). (Pregnant staff are strongly discouraged from providing direct care to radiologically contaminated patients in order to minimize the risk to the fetus.)

2. Facilities will be decontaminated to the extent possible. For some items, replacement may be more cost effective and practical than decontamination. Decisions on decontamination will be consistent with the ALARA philosophy (See Radiation Safety Manual, Section IV. and state law, Title 17, Section 30253). Areas of fixed contamination (radioactive material that cannot be easily removed from surfaces) may exist in patient care areas and will be labeled. Engineering controls (e.g. barriers, lead sheeting) will be used to reduce dose rates to staff and patients to less than 2 mrem per hour while decontamination efforts are completed. The goal will be to keep dose to staff to less than 100 mrem from fixed contamination while allowing the facility to remain operational.

* Does not apply to the McClellan Nuclear Radiation Center.

Reference:

1. The guidance from the National Council on Radiation Protection and Measurements Report No. 116, *Limitation of Exposure to Ionizing Radiation*, states that for life saving or equivalent purposes, workers may approach or exceed 50 rem to a large portion of the body and 500 rem to the skin. Emergency exposures are considered once-in-a-lifetime. This is well below the threshold for the acute radiation syndrome. An acute radiation dose of 500 rem to the skin would not result in any permanent skin damage.

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