Appendix D
Nuclear

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Radiation Facts

What is radiation?

Radiation is a form of energy. It comes from man-made sources such as x-ray machines, from the sun and outer space, and from some radioactive materials such as uranium in soil.

How can I be exposed to radiation?

Small quantities of radioactive materials occur naturally in the air we breathe, the water we drink, the food we eat, and in our own bodies. Radiation that goes inside our bodies causes what we refer to as **internal** exposure. The exposure that is referred to as **external** comes from sources outside the body, such as radiation from sunlight and man-made and naturally occurring radioactive materials.

Radiation doses that people receive are measured in units called "rem" or "sievert." (One sievert is equal to100 rem.) Scientists estimate that the average person in the United States receives a dose of about one-third of a rem per year. Eighty percent of typical human exposure comes from natural sources and the remaining 20 percent comes from artificial radiation sources, primarily medical x-rays.

What are the health effects of exposure to radiation?

Radiation can affect the body in a number of ways, and the adverse health consequences of exposure may not be seen 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 is 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.

How can I protect myself from radiation?

The three basic ways to reduce your exposure are through—
TIME: Decrease the amount of time you spend near the source of radiation.
DISTANCE: Increase your distance from a radiation source.
SHIELDING: Increase the shielding between you and the radiation source. Shielding is anything that creates a barrier between people and the radiation source. Depending on the type of radiation, the shielding can range from something as thin as a plate of window glass or as thick as several feet of concrete. Being inside a building or a vehicle can provide shielding from some kinds of radiation.

Where can I get more information about radiation?

More information can be obtained from the following U.S. government sources:

The Environmental Protection Agency

The Nuclear Regulatory Commission can be reached at (301) 415-8200

The Federal Emergency Management Agency (FEMA) can be reached at (202) 646-4600.

The Radiation Emergency Assistance Center/Training Site (REAC/TS) can be reached at (865) 576-3131 (ask for REAC/TS).

The U.S. Department of Energy (DOE) can be reached at 1-800-dial-DOE

Radiation & Health Effects

Radiation and Health

Radiation is a form of energy.
Radiation comes from man-made sources such as x-ray machines, from the sun and outer space, and from some radioactive materials such as uranium in soil.
Small quantities of radioactive materials occur naturally in the air we breathe, the water we drink, the food we eat, and even in our own bodies.
Radiation that goes inside our bodies causes what we refer to as **internal** exposure.
External exposure is from radiation from sources outside our body, such as radiation from sunlight and man-made and naturally occurring radioactive materials.
Radiation doses that people receive are measured in units called “rem” or “sievert.” (One sievert is equal to 100 rem.) Scientists estimate that the average person in the United States receives a dose of about one-third of a rem per year.
Eighty percent of typical human exposure comes from natural sources and 20 percent comes from artificial radiation sources, primarily medical X-rays.

Health Effects of Radiation Exposure

Radiation affects the body in different ways, but the adverse health consequences of exposure may not be seen for many years.
Adverse health effects range from mild effects, such as skin reddening, to serious effect such as cancer and death. These adverse health effects are determined by 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 is exposed.
Acute radiation syndrome (ARS), or radiation sickness, is usually caused when a person receives a high dose of radiation to much of the body in a matter of minutes. Survivors of the Hiroshima and Nagasaki atomic bombs and firefighters responding to the Chernobyl nuclear power plant event in 1986 experienced ARS. The immediate symptoms of ARS are nausea, vomiting, and diarrhea; later, bone marrow depletion may lead to weight loss, loss of appetite, feeling like you have the flu, infection, and bleeding. The survival rate depends on the radiation dose. For those who do survive, full recovery takes from a few weeks to 2 years.
Children exposed to radiation may be more at risk than adults. Radiation exposure to the unborn child is of special concern because the human embryo or fetus is extremely sensitive to radiation.
Radiation exposure, like exposure to the sun, is cumulative.

Protecting Against Radiation Exposure

The three basic ways to reduce radiation exposure are through:

TIME

Decrease the amount of time you spend near the source of radiation.

DISTANCE

Increase your distance from a radiation source.

SHIELDING

Increase the shielding between you and the radiation source. Shielding is anything that creates a barrier between people and the radiation source. Depending on the type of radiation, the shielding can range from something as thin as a plate of window glass or as thick as several feet of concrete. Being inside a building or a vehicle can provide shielding from some kinds of radiation.

Other Sources of Information about Radiation

The Environmental Protection Agency counterterrorism programs

The Nuclear Regulatory Commission can be reached at (301) 415-8200.

The Federal Emergency Management Agency (FEMA) can be reached at (202) 646-4600.

The Radiation Emergency Assistance Center/Training Site (REAC/TS) can be reached at (865) 576-3131 (ask for REAC/TS).

The U.S. National Response Team.

The U.S. Department of Energy (DOE) can be reached at 1-800-dial-DOE.

The state radiation control director can be found by contacting The Conference of Radiation Control Program Directors (CRCPD) at (502) 227-4543.

Emergency Medical Management Radiation Guidelines

1. Approach site with caution--look for evidence of hazardous materials.

2. If radiation hazard is suspected, position personnel, vehicles, and command post at a safe distance (approx. 150 feet) upwind and uphill of the site.

3. Notify proper authorities and hospital.

4. Put on protective gear and use dosimeters and survey meters if immediately available.

5.Determine whether injured victims are present.

6. Assess and treat life-threatening injuries immediately. Do not delay advanced life support if victims cannot be moved or to assess contamination status. Perform routine emergency care during extrication procedures.

7. Move victims away from the radiation hazard area, using proper patient transfer techniques to prevent further injury. Stay within the controlled zone if contamination is suspected.

8. Expose wounds and cover with sterile dressings.

9. Victims should be monitored at the control line for possible contamination only after they are medically stable. Radiation levels above background indicate the presence of contamination. Remove the contaminated accident victims' clothing, provided removal can be accomplished without causing further injury.

10. Move the ambulance cot to the clean side of the control line and unfold a clean sheet or blanket over it. Place the victim on the covered cot and package for transport. Do not remove the victim from the backboard if one was used.

11. Package the victim by folding the stretcher sheet or blanket over and securing them in the appropriate manner.

12. Before leaving the controlled area, rescuers should remove protective gear at the control line. If possible, the victim should be transported by personnel who have not entered the controlled area. Ambulance personnel attending victims should wear gloves.

13. Transport the victims to the hospital emergency department. The hospital should be given additional appropriate information, and the ambulance crew should ask for any special instructions the hospital may have.

14. Follow the hospital's radiological protocol upon arrival.

15. The ambulance and crew should not return to regular service until the crew, vehicle, and equipment have undergone monitoring and necessary decontamination by the radiation safety officer.

16. Personnel should not eat drink, smoke, etc., at the accident site, in the ambulance, or at the hospital until they have been released by the radiation safety officer.

Reference: Ricks, R.C., Prehospital/ Management of Radiation Accidents, ORAU 223, Oak Ridge Associated Universities, Oak Ridge, TN, 1984.

Radiation Emergencies

Guidance for Hospital Medical Management

Patient arrival and triage

Meet the radiation accident victim at the ambulance or at a triage area established near the treatment area. Instruct EMS personnel to stay with their vehicle until they, their vehicle, and equipment are surveyed and released by a radiation safety officer.

During triage, consideration is given to medical and radiological problems. **Serious medical problems always have priority over radiological concerns**, and immediate attention is directed to life-threatening problems. Radiation injury rarely causes unconsciousness or immediate visible signs of injury and is not immediately life threatening; therefore other causes of injury or illness **must** be considered.

Noncontaminated patients are admitted to the usual treatment area. ***Contaminated*** patients are admitted to a specially prepared area. When in doubt, a critically injured patient should be taken immediately into the prepared area. If the victim's condition allows, an initial, **brief** radiological survey can be performed to determine if the victim is contaminated. Any radiation survey meter reading above background radiation levels indicates the possibility of contamination. A more thorough survey will be performed once life-threatening problems are addressed.

The victim's contaminated clothing should be removed before arrival at the hospital (at the accident scene), if this can be accomplished without causing harm or delay. Otherwise, the clothing should be removed as promptly as possible (without compromising life or limb), using care to avoid spread of any contaminants embedded in or on the clothing. Clothing, and any accompanying sheets, blankets, etc. should be placed in a plastic bag. Care-givers should change gloves after handling clothing or other potentially contaminated items.

Assessment and treatment of the noncontaminated patient

Noncontaminated individuals can be cared for like any other emergency case. A specially prepared treatment area is not needed. Following attention to medical needs, question the patient to determine the possibility of radiation exposure from an external source. Remember, the victim of exposure without contamination poses no radiological hazard to anyone. If exposure is known or suspected, a stat CBC should be ordered with particular attention given to determining the absolute lymphocyte count. Be sure to record the time the blood sample is taken. For differential diagnosis, refer to acute radiation injury.

Assessment and treatment of the contaminated patient

Contaminated patients can have radioactive materials deposited on skin surfaces, in wounds, or internally (ingested, inhaled, or absorbed). Reassessment of the contaminated patient's airway, breathing, and circulation are done in the decontamination room prior to attention to the patient's radiological status. Level of consciousness and vital signs are assessed promptly and the patient's condition is stabilized. After examining the entire patient and identifying all injuries, a complete radiological survey should be done.

The patient should be questioned about allergies, currently used medications, any history of chronic or recent illness, and **recent nuclear medicine tests**. The patient's level of anxiety should be noted, and psychological support offered. A complete and detailed medical, occupational, and accident history should be taken, and a physical examination completed.

Certain clinical and radiological laboratory analyses (see Radiological and Clinical Laboratory Assessments section below) are essential to the care of the radiation accident patient. These laboratory tests are done to assess the biological effects of radiation injury; to identify abnormalities that might complicate treatment; to locate, identify, and quantify radionuclide contamination; and to provide information useful in accident.

Radiological and clinical laboratory assessments

All samples ***must*** be placed in separate, labeled containers that specify name, date, time of sampling, area of samples, and size of area samples. It is suggested that blood, urine, feces, or other samples taken in the emergency treatment period be retained for subsequent investigation. Appropriate advice (legal, radiation safety, etc.) should be obtained regarding the storage and disposition requirements of collected samples.

Samples Needed	Why?	How?
***In all cases of radiation injury*:**		
CBC and differential STAT (follow with absolute lymphocyte counts every 6 hours for 48 hours when history indicates possibility of total-body irradiation)	To assess the radiation dose; initial counts establish a baseline, subsequent counts reflect the degree of injury	Choose a noncontaminated area for veni-puncture; cover puncture site after collection
Routine urinalysis	To determine if kidneys are functioning normally and establish a baseline of urinary constituents; especially important if internal contamination is a possibility	Avoid contaminating specimen during collection; if necessary, give the patient plastic gloves to wear for collection of specimen; label specimen "Number 1," with date and time
***When external contamination is suspected*:**		
Swabs from body orifices	To assess possibility of internal contamination	Use separate saline- or water-moistened swabs to wipe the inner aspect of each nostril, each ear, mouth, etc.
Wound dressing and/or swabs from wounds	To determine if wounds are contaminated	Save dressings in a plastic bag. Use moist or dry swabs to sample secretions from each wound, or collect a few drops of secretion from each using a dropper or syringe; for wounds with visible debris, use applicator or long tweezers or forceps to transfer samples to specimen containers which are placed in lead storage containers (pigs)
***When internal contamination is suspected*:**		
Urine: 24-hour specimen x 4 days	Body excreta may contain radionuclides if internal contamination has occurred	Use 24-hour urine collection container
Feces x 4 days		

Decontamination of the contaminated patient

Good judgement is essential in determining decontamination priorities. Since some radioactive materials are corrosive or toxic because of their chemical properties, medical attention might have to be directed first to a non-radiological problem if radioactive materials are components of acids, fluorides (uranium hexafluoride-UF_6), mercury, lead, or other compounds.

In general, contaminated wounds and body orifices are decontaminated first, followed by areas of highest contamination levels on the intact skin. The purpose of decontamination is to prevent or reduce incorporation of the material (internal contamination), to reduce the radiation dose from the contaminated site to the rest of

the body, to contain the contamination, and to prevent its spread. Please note that frequent glove changes will be necessary.

Treatment of contaminated wounds

In a contamination accident, any wound must be considered contaminated until proven otherwise and **should be decontaminated prior to decontaminating intact skin**. When wounds are contaminated, the physician must assume that uptake (internal contamination) has occurred. Appropriate action is based on half-life, radiotoxicity, and the amount of radioactive material. It is important to consult experts as soon as possible and to initiate measures that prevent or minimize uptake of the radioactive material into body cells or tissues.

Contaminated wounds are first draped, preferably with a waterproof material, to limit the spread of radioactivity. Wound decontamination is accomplished by gently irrigating with saline or water. More than one irrigation is usually necessary. The wound should be monitored after each irrigation. Contaminated drapes, dressings, etc., should be removed before each monitoring for accurate results. When monitoring contaminated wounds or irrigation fluids, gamma radiation is easily detected while beta radiation may prove more difficult to detect. Without special, highly sophisticated wound probes, alpha contamination will not be detected. Following repeated irrigations, the wound is treated like any other wound. If the preceding decontamination procedures are not successful, and the contamination level is still seriously high, conventional debridement of the wound must be considered. Excision of vital tissue should not be initiated until expert medical or health physics advice is obtained. Debrided or excised tissue should be retained for health physics assessment.

Embedded radioactive particles, if visible, can be removed with forceps or by using a water-pik. Puncture wounds containing radioactive particles, especially in the fingers, can be decontaminated by using an "en bloc" full thickness skin biopsy using a punch biopsy instrument.

After the wound has been decontaminated, it should be covered with a waterproof dressing. The area around the wound is decontaminated as thoroughly as possible before suturing or other treatment.

Contaminated burns (chemical, thermal) are treated like any other burn. Contaminants will slough off with the burn eschar. However, dressings and bed linens can become contaminated and should be handled appropriately.

Decontamination of body orifices

Contaminated body orifices, such as the mouth, nose, eyes, and ears need special attention because absorption of radioactive material is likely to be much more rapid in these areas than through the skin.

If radioactive material has entered the oral cavity, encourage brushing the teeth with toothpaste and frequent rinsing of the mouth. If the pharyngeal region is also contaminated, gargling with a 3-percent hydrogen peroxide solution might be helpful. Gastric lavage may also be used if radioactive materials were swallowed. Contaminated eyes should be rinsed by directing a stream of water from the inner canthus to the outer canthus of the eye while avoiding contamination of the nasolacrimal duct. Contaminated ears require external rinsing, and an ear syringe can be used to rinse the auditory canal, provided the tympanic membrane is intact.

External contamination

Decontamination of the intact skin is a relatively simple procedure. Complete decontamination, which returns the area to a background survey reading, is not always possible because some radioactive material can remain fixed on the skin surface. Decontamination should be only as thorough as practical.

Decontamination should begin with the least aggressive method and progress to more aggressive ones. Whatever the procedure, take care to limit mechanical or chemical irritation of the skin. The simplest procedure is to wash the contaminated area gently under a stream of water (do not splash) and scrub at the same time using a soft brush or surgical sponge. Warm, never hot, tap water is used. Cold water tends to close the pores, trapping radioactive material within them. Hot water causes vasodilation with increased area blood flow, opens the pores, and enhances the chance of absorption of the radioactive material through the skin. **Aggressive rubbing tends to cause abrasion and erythema and should be avoided.**

If washing with plain water is ineffective, a mild soap (neutral pH) or surgical scrub soap can be used. The area should be scrubbed for 3 to 4 minutes, then rinsed for 2 to 3 minutes and dried, repeating if necessary. Between each scrub and rinse, check the contaminated area to see if radiation levels are decreasing. Sodium hypochlorite, diluted 1 to 10 with water, is an effective decontamination agent. A mildly abrasive soap (a 1 to 1 mixture of powdered detergent and cornmeal mixed with water into a paste) can be used for calloused areas. **The decontamination procedure stops when the radioactivity level cannot be reduced to a lower level.** Expert advice might be needed to determine an appropriate stopping point. Contaminated hairy areas can be shampooed several times. Contaminated hair can be clipped if shampooing is ineffective. Shaving should be avoided since small nicks or abrasions can lead to internal contamination. When shampooing the head, avoid getting any fluids into the ears, eyes, nose, or mouth.

Ambulatory patients with localized contamination can be decontaminated using a sink or basin. If extensive body areas are contaminated, the patient can be showered under the direction or with the assistance of a radiation safety officer. Caution the patient to avoid splashing water into the eyes, nose, mouth, or ears. Repeated showers might be necessary, and clean towels provided for drying after each shower. Again, decontamination should be as thorough as practical.

Although it may be desireable that the wastewater from decontamination procedures be retained and analyzed before being discharged into the sanitary sewer, this requirement should not be mandatory. Furthermore, the installation of an elaborate holding system is not likely to be justified because of the infreqency of the event. The welfare of the patient should come first, and the physician should feel free to use whatever facilities are readily available to accomplish that end. Any radiation hazard to the general public will be virtually eliminated when the inherently small and infrequent volume of radioactive waste is mixed with and diluted by other sewage effluents of the hospital and community (AMA, 1984).

Patient comfort and emotional support

A patient involved in a radiation accident needs explanations of procedures and actions being taken (isolation, use of survey meters, taking of samples, decontamination, etc.) in the radiation emergency area. A knowledgeable person should answer the patient's questions and provide reassurance. For example, explain use of protective clothing and surgical masks during treatment. Following initial care and treatment, someone with a knowledge of radiation effects should spend adequate time answering the patient's questions. Preferably, this person should be the attending physician who continues to treat the patient until discharge. Reporters and news-hunters should get their reports from the hospital's public information officer.

Patient safety

Routine precautions for patient safety should not be forgotten. Be especially alert for potential falls or slips on wet floors, excessive heating or chilling, and electrical hazards.

Documentation

In addition to routine medical records, note survey readings, samples taken (and time), descriptions of the accident, and the effectiveness of decontamination. Take care to note pre-existing conditions such as rashes, healing wounds, or scars. This information will be extremely valuable to medical consultants and health physicists in reconstructing the accident accurately and making a prognosis.

Post-emergency patient transfer

A final complete-body survey is performed following decontamination procedures. A new floor covering is laid from the clean area to the patient stretcher. A clean stretcher

is brought in, the patient is transferred to it by clean attendants (those involved in the decontamination procedure may now be contaminated), and the patient is wheeled to the door. After the radiation safety officer makes a final check of the patient and the stretcher (especially the wheels), the patient is taken from the room.

Staff exit from the controlled area

Each member of the decontamination team goes to the control line and removes his protective clothes as described below:

1. Remove outer gloves first, turning them inside-out as they are pulled off.

2. Give dosimeter to radiation safety officer.

3. Remove all tape at trouser cuffs and sleeves.

4. Remove outer surgical gown, turning it inside-out -- avoid shaking.

5. Pull surgical trousers off over shoe covers.

6. Remove head cover and mask.

7. Remove shoe cover from one foot and let radiation safety officer monitor shoe; if shoe is clean, step over control line, then remove other shoe cover and monitor other shoe.

8. Remove inner gloves.

9. Do total-body radiological survey of each team member.

10. Take shower.

After staff exit, the decontamination room should be secured and a sign reading "**CAUTION -- CONTROLLED AREA -- DO NOT ENTER**" should be posted. Unless it is needed for emergency medical reasons, the decontamination room remains secured until it can be checked and decontaminated, if necessary, by the radiation safety officer or other health physics expert.

Acute Radiation Syndrome

Acute radiation syndrome (ARS) is an acute illness caused by irradiation of the whole body (or a significant portion of it). It follows a somewhat predictable course and is characterized by signs and symptoms which are manifestations of cellular deficiencies and the reactions of various cells, tissues, and organ systems to ionizing radiation.

Immediate, overt manifestations of the acute radiation syndrome require a large (i.e., hundreds of rem, usually whole-body) dose of penetrating radiation delivered over a short period of time. Penetrating radiation comes from a radioactive source or machine that emits gamma rays, X-rays, or neutrons. The signs and symptoms of this syndrome are non-specific and may be indistinguishable from those of other injuries or illness.

The ARS is characterized by four distinct phases: a prodromal period, a latent period, a period of illness, and one of recovery or death. During the prodromal period patients might experience loss of appetite, nausea, vomiting, fatigue, and diarrhea; after extremely high doses, additional symptoms such as fever, prostration, respiratory distress, and hyperexcitability can occur. However, all of these symptoms usually disappear in a day or two, and a symptom-free, latent period follows, varying in length depending upon the size of the radiation dose. A period of overt illness follows, and can be characterized by infection, electrolyte imbalance, diarrhea, bleeding, cardiovascular collapse, and sometimes short periods of unconsciousness. Death or a period of recovery follows the period of overt illness.

In general, the higher the dose the greater the severity of early effects and the greater the possibility of late effects.

Depending on dose, the following syndromes can be manifest:

> Hematopoietic syndrome - characterized by deficiencies of WBC, lymphocytes and platelets, with immunodeficiency, increased infectious complications, bleeding, anemia, and impaired wound healing.
> Gastrointestinal syndrome - characterized by loss of cells lining intestinal crypts and loss of mucosal barrier, with alterations in intestinal motility, fluid and electrolyte loss with vomiting and diarrhea, loss of normal intestinal bacteria, sepsis, and damage to the intestinal microcirculation, along with the hematopoietic syndrome.
> Cerebrovascular/Central Nervous System syndrome - primarily associated with effects on the vasculature and resultant fluid shifts. Signs and symptoms include vomiting and diarrhea within minutes of exposure, confusion, disorientation, cerebral edema, hypotension, and hyperpyrexia. Fatal in short time.
> Skin syndrome - can occur with other syndromes; characterized by loss of epidermis (and possibly dermis) with "radiation burns."

Initial Emergency Management:

If trauma is present, treat.

If external contaminants are present, decontaminate.

Diagnosis:

History of exposure - consider acute radiation syndrome in the differential diagnosis if there is:

a history of a known or possible radiation exposure (for example, entering an irradiation chamber when the source is unshielded)

a history of proximity to an unknown (usually metallic) object with a history of nausea and vomiting, especially if n/v are unexplained by other causes

a tendency to bleed (epistaxis, gingival bleeding, petechiae) and/or respiratory infection with neutropenia, lymphopenia, and thrombocytopenia, with history of nausea and vomiting two to three weeks previously

epilation, with a history of nausea and vomiting two to three weeks previously

Symptom - type of symptom, time of onset, severity, and frequency.

Clinical lab - STAT CBC with differential. Repeat in 4-6 hours, then every 6 to 8 hours for 24 to 48 hours. Look for a drop in the absolute lymphocyte count if the exposure was recent. If the initial WBC and platelet counts are abnormally low, consider the possibility of exposure a few days to weeks earlier.

Acute Radiation Syndrome: Dose Less Than 2 Gy (200 rad)

Nausea and vomiting due to radiation are seldom experienced unless the exposure has been at least 0.75 to 1 Gy (75-100 rads) of penetrating gamma or X-rays and it has occurred within a matter of a few hours or less. The prospective patient who has been asymptomatic within the past 24 hours will most certainly have had less than 0.75 Gy of whole-body exposure. Hospitalization generally will be unnecessary if the dose has been less than 2 Gy (200 rads).

Management of ARS (dose <2 Gy):

Close observation and frequent CBC with differential.

Outpatient management may be appropriate.

Provide instructions regarding home care.

Acute Radiation Syndrome: Dose Greater Than 2 Gy (200 rad)

Signs and symptoms become increasingly severe with dose.

Hematopoietic Syndrome:

The prodromal phase - nausea, vomiting and anorexia within a few hours at the higher dose levels, or after 6 to 12 hours at the lower dose levels. Lasts 24 to 48 hours, after which time the patient is asymptomatic and may feel well. The absolute lymphocyte count will fall; a stress response of WBC may be present.

The latent phase - lasts a few days to as long as 2 to 3 weeks at the lower dose levels. The patient is asymptomatic but CBCs will show characteristic changes in the blood elements, with lymphocyte depression and gradual decrease in neutrophil and platelet counts.

A bone marrow depression phase requires sophisticated treatment. Infection and hemorrhage could occur when white cell and platelet counts become critically low.

The recovery phase - stem cells in the bone marrow are never completely eradicated at 2 to 10 Gy (200 to 1000 rads); some may replicate and eventually produce sufficient blood elements. Supportive therapy is required.

Gastrointestinal Syndrome:

Over 10 Gy (1000 rads) - this syndrome is distinguishable from the hematopoietic syndrome by the immediate, prompt and profuse onset of nausea, vomiting and diarrhea, followed by a short latent period. GI symptoms recur and lead to marked dehydration, and vascular effects. The GI mucosa becomes increasingly atrophic, and massive amounts of plasma are lost to the intestine. Massive denuding of the GI tract and accompanying septicemia and dehydration can occur. If the patient survives long enough, depression of the hematopoietic system occurs and complicates the clinical course.

Cardiovascular Syndrome:

Over 30 Gy (3000 rads), an extremely high dose, to the whole-body. Always fatal, there is immediate nausea, vomiting, anorexia and prostration, and irreversible hypotension; blood pressure will be markedly unstable. Within hours after exposure, the victim will be listless, drowsy, tremulous, convulsive, and ataxic. Death most likely will occur within a matter of days.

Management of Acute Radiation Syndrome (Dose >2 Gy)
Initial management:

Vomiting - use selective blocking of serotonin 5-HT_3 receptors or use 5-HT_3 receptor antagonists.

Consider initiating viral prophylaxis.

Consider tissue, blood typing.

Treat trauma.

Consider prompt consultation with hematologist and radiation experts, re: dosimetry and prognosis, use of colony stimulating factors, stem cell transfusion, and other treatment options.

Draw blood for chromosome analysis; use heparinized tube.

Note areas of erythema and record on body chart. If possible, take photographs.

Begin, <u>as indicated</u>:

SUPPORTIVE CARE in a CLEAN environment (reverse isolation).

Prevention and treatment of infections.

Stimulation of hematopoiesis (use of growth factors, i.e., GCSF, GMCSF, interleukin 11).

Stem cell transfusions: cord blood, peripheral blood, or bone marrow. Platelet transfusions if bleeding occurs or if platelet count too low.

Psychological support.

Observe carefully for erythema (document locations), hair loss, skin injury, mucositis, parotitis, weight loss, and/or FEVER.
Consultation with experts in radiation accident management is encouraged.

Treatment of Internal Contamination

Once radioactive materials cross cell membranes, they are said to be incorporated. Incorporation is a time-dependent, physiological phenomenon related to both the physical and chemical natures of the contaminant. Incorporation can be quite rapid, occurring in minutes, or it can take days to months. Thus, time can be critical and prevention of uptake is urgent. Several methods of preventing uptake (e.g., catharsis, gastric lavage) might be applicable and can be prescribed by a physician. Some of the medications or preparations used in decorporation might not be available locally and should be stocked when a decontamination station is being planned and equipped. Examples of specific agents used for selected radionuclides can be seen in the table below. Expert guidance is available from NCRP 65, poison control centers, or call REAC/TS (865-576-3131) or the 24-hour emergency number (865-576-1005).

If internal contamination is suspected or has occurred, the physician or radiation safety officer should request samples of urine, feces, vomitus, wound secretion, etc. Whole-body counting and radioassay can help evaluate the magnitude of the problem and the effect of any treatment. The contaminated patient admitted with an airway or endotracheal tube must be considered to be internally contaminated.

Radionuclide	Medication	For Ingestion/Inhalation	Principle of Action
Iodine	KI (potassium iodide)	130 mg (tabl) stat, followed by 130 mg q.d. x 7 if indicated	Blocks thyroid deposition
Rare earths Plutonium Transplutonics Yttrium	Zn-DTPA Ca-DTPA	1 gm Ca-DTPA (Zn-DTPA) in 150-250 ml 5 percent D/W IV over 60 minutes	Chelation
Uranium	Bicarbonate	2 ampules sodium bicarbonate (44.3 mEq each; 7.5%) in 1000 cc normal saline @ 125 cc/hr; alternately, oral administration of two bicarbonate tablets every 4 hours until the urine reaches a pH of 8-9	Alkalinization of urine; reduces chance of acute tubular necrosis
Cesium Rubidium Thallium	Prussian Blue [Ferrihexacyano-Ferrate (II)]	1 gm with 100-200 ml water p.o. t.i.d. for several days	Blocks absorption from GI tract and prevents recycling.
Tritium	Water	Force fluids	Isotopic dilution

Sheltering in Place During a Radiation Emergency

With recent terrorist events, many people have wondered about the possibility of a terrorist attack involving radioactive materials. People who live near but not in the immediate area of the attack may be asked to stay home and take shelter rather than try to evacuate. This action is called “sheltering in place.” Because many radioactive materials rapidly decay and dissipate, staying in your home may protect your from exposure to radiation. The thick walls of your home may block much of the harmful radiation. Taking a few simple precautions can help you reduce your exposure to radiation. The Centers for Disease Control and Prevention has prepared this fact sheet to help you protect yourself and your family and to help you prepare a safe and well-stocked shelter.

Preparing a Shelter in Your Home

The safest place in your home during an emergency involving radioactive materials is a centrally located room or basement. This area should have as few windows as possible. The further your shelter is from windows, the safer you will be.

Preparation is the key. Store emergency supplies in this area. An emergency could happen at any time, so it is best to stock supplies in advance and have everything that you need stored in the shelter.

Every 6 months, check the supplies in your shelter. Replace any expired medications, food, or batteries. Also, replace the water in your shelter every 6 months to keep it fresh.

Make sure that all family members know where the shelter is and what it is for. Caution them not to take any items from that area. If someone “borrows” items from your shelter, you may find that important items are missing when they are most needed.

If you have pets, prepare a place for them to relieve themselves in the shelter. Pets should not go outside during a radiation emergency because they may track radioactive materials from fallout into the shelter. Preparing a place for pets will keep the radioactive materials from getting inside the shelter.

Preparing Emergency Supplies

Stock up on supplies, just as you would in case of severe weather conditions or other emergencies. Following is a list of things to consider when preparing your emergency kit.

> **Food with a long shelf life** – Examples of this include canned, dried, and packaged food products. Store enough food for each member of the household for at least 3 days.
> **Water** – In preparation for an emergency, purchase and store bottled water or simply store water from the tap. Each person in the household will need about 1 gallon per day; plan on storing enough water for at least 3 days.

A change of clothes and shoes – Check clothing every 6 months and remove clothes that no longer fit or are unsuitable for seasonal weather. Remember to include underwear, socks, sturdy shoes or work boots, and winter or summer clothes as needed.

Paper plates, paper towels, and plastic utensils – Store disposable dishware and utensils because you will not have enough water to wash dishes and because community water sources may be contaminated.

Plastic bags – Because you may not be able to leave your shelter for several days, you will need to collect your waste in plastic bags until it can be removed.

Bedding – Store sheets, blankets, towels, and cots for use during the time that you cannot leave your shelter.

Battery-operated radio and batteries – Electrical power may not be on for several days. A battery-operated radio will allow you to listen to emergency messages.

Medicines – Have 2-3 days' dose of your current prescription medicines in a childproof bottle for your shelter medical kit; label with the name and expiration date of the medicine. (Discuss with your doctor the best way to obtain this small amount of extra medicine.) Be sure to check medicines in your kit every 6 months to make sure they are not past the expiration date.

Toiletries – Keep a supply of soap, hand sanitizer, toilet paper, deodorant, disinfectants, etc.

Flashlight and batteries – Electrical power may be out for several days. A flashlight will help you see in your shelter.

A telephone or cell phone – Although cell phone or ground phone service may be interrupted, there is still a chance that you will be able to use a phone to call outside for information and advice from emergency services.

Extra eyeglasses or contact lenses and cleaning supplies.

Duct tape and heavy plastic sheeting – You can use these items to seal the door to your shelter and to seal any vents that open into your shelter for a short period of time if a radiation plume is passing over.

Pet food, baby formula, diapers, etc. – Don't forget the other members of your family. If you have an infant, store extra formula and diapers. If you have pets keep a 3-day supply of pet food.

First aid kit – You can purchase a first-aid kit or prepare one yourself. Be sure to include the following items:

- Sterile adhesive bandages
- Sterile gauze pads in 2 inch and 4 inch sizes
- Adhesive tape
- Sterile rolled bandages
- Scissors
- Tweezers
- Needle
- Thermometer
- Moistened towelettes
- Antiseptic ointment
- Tube of petroleum jelly or other lubricant
- Soap or hand sanitizer
- Latex or vinyl gloves
- Safety pins
- Aspirin or aspirin free pain reliever
- Antidiarrhea medication
- Laxatives
- Antacids for stomach upset
- Syrup of ipecac to cause vomiting if advised by the Poison Control Center
- Activated charcoal to stop vomiting if advised by the Poison Control Center

Games, books and other entertainment – Because you may be in your shelter for several days, keep items on hand to occupy your family during that time. Children are likely to get bored if they have to stay in one place for long periods. Think of activities that they will enjoy doing while in the shelter – finger painting, coloring, playing games, etc.

Tips Before Entering a Shelter

If you are outside when the alert is given, try to remove clothing and shoes and place them in a plastic bag before entering the house. During sever weather, such as extreme cold, remove at least the outer layer of clothes before entering the home to avoid bringing radioactive material into your shelter. Leave clothing and shoes outside. Shower and wash your body with soap and water. Removing clothing will eliminate 90% of radioactive contamination. By taking this simple step, you will reduce the time that you are exposed and also your risk of injury from the radiation.

Before entering the shelter, turn off fans, air conditioners, and forced-air heating units that bring air in from the outside. Close and lock all windows and doors, and close fireplace dampers.

When you move to your shelter, use duct tape and plastic sheeting to seal any doors,

windows, or vents for a short period of time in case a radiation plume is passing over (listen to your radio for instructions). Within a few hours, you should remove the plastic and duct tape and ventilate the room. Suffocation could occur if you keep the shelter tightly sealed for more than a few hours.

Keep your radio tuned to an emergency response network at all times for updates on the situation. The announcers will provide information about when you may leave your shelter and whether you need to take other emergency measures