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INTRODUCTION

In this module, you will learn about the importance of conducting a patient assessment and the priorities for treatment of the radiation accident victim. You will learn about sample collection for clinical and radiological analysis and techniques for external decontamination. Treatment strategies for internally contaminated patients and treatment measures for irradiated patients are also covered.

PURPOSE

The purpose of this module is to increase your understanding of proper patient care with the radiation accident victim. This knowledge will help you appropriately care for patients who are contaminated with radioactive material and/or have received a large acute dose of ionizing radiation.

MODULE OBJECTIVES

Upon completion of this module, you will be able to:

1. Identify the steps in patient assessment and decontamination.
2. Identify specimens that should be collected for clinical and radiological assessment.
3. Identify treatment options for externally and internally contaminated patients.
4. Identify appropriate procedures for decontamination of patients and staff.

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PATIENT ASSESSMENT AND TRIAGE

Ideally, your hospital will have detailed plans for decontamination operations and you will have reviewed these. Thus, enabling you to begin with the normal process involved in a hazardous material or radiation incident. The following module assumes that care for coexistent conventional injuries and medical problems are being provided in accordance with accepted local protocols and standards of care.

DECONTAMINATION

Types of Decontamination

- Gross decontamination is the removal of the majority of the contaminant. Typically, gross decon is performed at the scene by emergency responders. It must be assumed that some residual contamination will remain on the patient after gross decontamination. This residual contamination can produce cross-contamination.
- Secondary decontamination is the removal of most of the residual product contamination. It provides a more thorough decontamination than the gross effort. Some residual contaminant may still remain even after secondary decontamination.

Purpose of Decontamination

Decontamination is performed for the following reasons:

- To decrease exposure to radiation for both patient and staff
- To prevent the spread of radioactive material to uncontaminated areas of the patient's body, staff, other patients, equipment, etc.
- To prevent or decrease internalization/incorporation of radioactive material

Emergent Decontamination

Emergent decontamination is rarely necessary. Initial (emergent) decontamination may be needed if the level of contamination is so high that the radiation being emitted constitutes an ongoing hazard to the patient and caregivers. In this case, a gross decontamination sufficient to reduce radiation to acceptable levels would be required. This is exceedingly rare, but possible in accidents such as an explosion in which the patient is impaled with a piece or pieces of highly radioactive material.

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Most of the patients that emergency department and pre-hospital personnel care for will be asymptomatic with respect to radiation injury. If symptoms of acute radiation syndrome are present, the patients will be in the prodrome stage, with most of the symptoms being non-specific (nausea, vomiting, etc.). Patients experiencing these symptoms shortly after exposure will have likely received a large, probably fatal dose of radiation, and this should be kept in mind during triage.

Keep in mind, too, that the symptoms of the prodrome are non-specific, and that there are many other causes of these symptoms, including head injury, abdominal injury, and fright. Symptomatic care can be given, such as intravenous fluids and antiemetics for nausea and vomiting, analgesics for pain, etc. This will be in addition to the care given for conventional medical problems.

RECEIVING THE PATIENT

The hospital should follow its normal protocol for receiving radiation accident victims or victims contaminated with an unknown hazardous material.

Triage

Triage is the process of rapidly sorting and categorizing patients based on the severity of their injuries and the urgency of their need for treatment. In most systems, the patients are placed into one of four categories. You should follow the procedures prescribed by your jurisdiction.

Triage Categorization

- RED – Emergent. Imminent threat to life or limb. Requires emergency treatment and transport to appropriate facility.
- YELLOW – Urgent. Less serious than red, but requires timely treatment and transport.
- GREEN – "Walking Wounded." Requires treatment, but may be delayed.
- BLACK – Expectant/Expired or Mortally Wounded. These are the dead, or those with unsurvivable injuries such as eviscerations, open skull fracture with brain disruption, etc.

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TYPES OF EXPOSURE

In a radiation incident, you may encounter three general classes of patients who may be classified under one or more of the conditions listed below: *Please note that a patient may experience a combination of any of these conditions.*

1. **Patient Exposed to Radiation from an External Source**
   A patient exposed to radiation alone will not pose a contamination problem. The degree of radiation-induced injury depends on the radiation dose received. It is important to remember that a patient exposed to radiation from an external source is not radioactive or contaminated and can be handled without fear or concern of spreading contamination to you or the environment.
2. **Externally Contaminated Patient**
   Coming into contact with radioactive material (gas, liquid, or solid) that has been released into the environment can contaminate a patient. Externally contaminated patients may have radioactive material on portions of their bodies or clothing. This contamination, if spread, presents a potential hazard to a hospital environment and to other people. If you suspect external contamination and the patient is seriously injured, give lifesaving assistance immediately. Contaminated patients should be handled with protocols (i.e., Universal Precautions) similar to those used for bloodborne pathogens.

   In order to limit the spread of contamination, wear protective clothing while handling an externally contaminated patient. Wrap the patient in a blanket or sheet during movement, and save all related clothing and bedding in plastic bags. Identify the bags clearly as "RADIOACTIVE - DO NOT DISCARD."

   A patient may also have contamination in, or near, a wound. An open cut or wound can allow contamination to enter the body, causing internal contamination. The primary objective must be to treat the wound and prevent further spread of radioactive contamination into it.

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3. Internally Contaminated Patient

A patient can become internally contaminated if radioactive material is inhaled, ingested, or introduced to the body through a cut or wound. Internally contaminated patients present minimal risk to response personnel.

The internally contaminated patient may also be externally contaminated and, if so, must be treated using the procedures described earlier. The internally contaminated patient will require specialized treatment to prevent further uptake of the contaminant and/or to promote its removal from the body.

PRIORITY OF TREATMENT

The patient involved in a radioactive material incident will often also have coinciding conventional injuries/medical problems due to the accident that caused the contamination or radiation exposure (vehicle accident, fall, explosion, etc.). This presents the triage officer with two different triage problems—the non- radiological and the radiological.

Non-radiological vs. Radiological Problems

Non-radiological problems center on conventional medical problems (i.e., those that are presented by injury and illness such as lacerations, splenic injury, pneumothorax, etc.). Radiological problems are caused by radiation exposure or contamination with radioactive materials. Serious conventional problems will always take precedence over the treatment of radiological problems. The key reasons for this are:

1. Conventional life-threats are treatable, and treatment can save a life, whereas failure to treat can cause death.
2. A person who is critically ill from radiation exposure alone and in need of emergency treatment within the first several hours, will have received a massive dose of radiation. Survival will be impossible.

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PRIMARY ASSESSMENT

Primary assessment is the initial, rapid assessment and treatment for life threats—the ABCs (airway, breathing, and circulation).

Basic Guidelines for Primary Assessment

1. A properly-suited team should meet the patient at the ambulance entrance. The triage officer or physician should begin a primary assessment. The radiation safety officer should also begin a gross survey for the presence, and amount, of radiological contamination. In addition, the radiation safety officer should make an assessment of the degree of danger to caregivers (i.e., is emergent decontamination needed?).
2. If it is determined that the patient is unstable and requires acute treatment, then he or she should be admitted to the REA and life-threats should be stabilized.
3. If it is determined that the patient is stable and does not require immediate treatment, a more detailed survey for contamination can be performed.
   a. If contamination is found, admit the patient to the REA for treatment and decontamination.
   b. If the patient is not contaminated, he or she can be admitted to the regular emergency department for care, as any other patient would be.

Methods of Assessment for Radiological Contamination

Body surveys and wound surveys are the two methods used to assess the patient for radiological contamination.

Body Survey

It is important that a body survey for radiological contamination be done in a methodical, careful fashion to avoid missing any contaminated areas.

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Procedures for Conducting a Body Survey

1. Turn on the appropriate survey meter and follow the manufacturer's recommended pre-operational procedures.
2. Cover the meter probe with a glove, plastic bag, etc., to prevent contamination of the probe should it accidentally touch a contaminated area. If the probe cover should become contaminated, the cover can simply be changed. If the probe itself should become contaminated, it may be impossible to decontaminate it adequately. In this case, it will be useless and may need to be disposed of as contaminated waste. Be aware that covering the probe will prevent it from detecting alpha radiation.
3. Establish a method and pattern of surveying to avoid missing any areas. A convenient method is to start at the top of the head and work your way down both front and back. Be sure to survey under arms, chin, etc. Pay special attention to the portals of entry, such as the mouth, nose, etc.
4. Begin your survey. Hold the probe approximately one-half to one inch from the surface being surveyed. Slowly move the probe, covering one to two inches per second. The response of the meter is not instantaneous. If the probe is moved too quickly, the meter may not respond and areas of contamination will be missed.
5. It is recommended that you use the instrument's audible response while surveying. This will allow you to watch the probe, rather than the meter. However, evaluate the use of the instrument's audible response while surveying the patient. If the patient is conscious, they may hear the audible response and become frightened. In this case, it may be best to forego the use of the audible response.
6. When areas of contamination are located, note them on the appropriate form indicating both location and approximate field strength in counts per minute (CPM). Commercially available burn forms are useful for this purpose.

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Wounds: Mechanisms for Entry of Radioactive Material

Radioactive material can enter wounds through several mechanisms as described below:

- Deposition by the object causing the wound, such as a sharp piece of contaminated metal.
- Deposition after wounding, such as a splash, spill, or spray of contaminated material.
- Blast injury driving the material into the wound. This may be the most difficult to detect and treat because the material may be driven deeply into and under the skin.
- Crush injury driving the material into the wound. The material may be lodged deeply in the wound or under the wound, in which case large amounts of tissue would be destroyed.

Wound Surveys

A wound survey can present a challenge. The detection of alpha emitters will require the use of special wound probes that can be inserted into the wound to detect contamination. This is due to the fact that a thin covering of blood or a thin layer of tissue, such as a skin flap, will effectively shield alpha radiation making it impossible to detect with standard alpha probes. Also, remember that the probe on many survey meters does not detect or measure alpha radiation.

For beta and gamma emitters, open wounds should be carefully surveyed with a covered probe. This will readily detect gamma-emitting radioisotopes. Detection of beta emitters will vary depending on the depth of the contamination (amount of blood and tissue covering/shielding the radioisotope). The probe covering may also affect detection of beta-emitting radioisotopes

SAMPLE COLLECTION

In an accident involving radioactive material, numerous samples are required, both for clinical evaluation of contamination and for accident reconstruction and analysis. Substances that would normally be disposed of will need to be saved.

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As with any situation, a complete and detailed medical, occupational, and accident history should be taken, and a physical examination completed. Certain clinical and laboratory analyses are also essential. These lab tests are completed 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 analysis.

A summary of some of the required samples appears in attachment 1 at the end of this module on pages 24 and 25. All samples should be placed in a sealed container. The label on the container should specify the exact location (such as left nostril, right nostril, etc.) from which the sample was taken, as well as the exact time the sample was taken, and the patient's identifying information (name, number, etc.)

TREATMENT OF EXTERNALLY CONTAMINATED PATIENTS

External Decontamination

External contamination refers to contamination on the surface of the body and the clothing. In general, about 80 percent or more of the external contamination will be on the outer clothing and 20 percent or less on the body surface. This type of contamination is the easiest to remove and the least harmful.

The goals of external decontamination are as follows:

- To prevent the spread of contamination
- To prevent the internalization/incorporation of contamination
- To decrease exposure to radiation by removal of the radioactive material

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Guidelines for External Decontamination

The following are guidelines for external decontamination. Keep in mind that decontamination can be a repetitive process.

1. Once the contamination is found, sample the area to determine the level of contamination, the isotope(s) involved, and to provide documentation regarding the contaminant. Place all samples in separate containers and label them with the patient's name, etc. as well as the exact location from which the sample is taken (left nostril, right volar proximal forearm, etc.). Label the time when the decontamination process sample was taken, this allows correlation with decontamination efforts.
2. Isolate the area with barriers that will prevent contamination spread during decontamination efforts.
3. Carry out decontamination procedures using mild soap and lukewarm water.
4. Remove barriers.
5. Resurvey the area to determine if contamination remains, and to what degree.
6. Repeat steps 1 through 5 until contamination is removed, no further decrease is accomplished, or contamination is reduced to an acceptable level (contamination will rarely be reduced to background levels). This will usually be determined by the physician, hospital radiation safety officer (RSO)/health physicist, or in consultation with the Idaho Radiation Control Program, or other authority as may be required.
7. Save everything that is removed from the patient, including samples of irrigating fluids if required by the RSO. Waste irrigants can often be disposed of in the hospital sanitary system, but should not be done without prior approval from the Idaho Radiation Control Program or Nuclear Regulatory Commission.

EXTERNAL DECONTAMINATION PRIORITIES

To prevent internalization/incorporation, the portals of entry (wounds, mouth, eyes, nose, and ears) should be addressed before intact skin. Likewise, areas of highest contamination should be addressed before areas of lower contamination; however, this is not a hard and fast rule.

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Portals of Entry
Contaminated body orifices, such as the mouth, nose, eyes, and ears, need special attention because radioactive material is more rapidly absorbed in these areas than through the skin.

Decontamination of the Mouth
Material may be deposited in the mouth by a splash, accidental ingestion, or from airborne particles.

Procedures to Decontaminate the Mouth
1. Sample under the tongue with swabs and in the buccal recesses between teeth and lips.
2. Remove any foreign materials, false teeth, or other removable dental work from the mouth and save them for radiological assay.
3. Brush teeth, gargle, and wash mouth. Be careful not to make gums bleed because this creates a break in a barrier and provides a new portal of entry.
4. If significant quantities of radioactive material/contamination are swallowed, emesis or gastric lavage may be required if not contraindicated by the chemical nature of the substance, the patient's medical status, etc.
5. If the patient vomits, emesis should be saved for assay for radioactive contaminants.

Decontamination of the Nose
Material may be deposited in the nasal hairs or on the mucosa by a splash or from airborne particles.

Procedures to Decontaminate the Nose
1. Sample each nostril individually with a swab moistened with saline. Place each swab in a container labeled with the patient's identifying information and identify which nostril the sample was collected from.
2. Remove any foreign materials from the nose and save them for radiological assay.
3. Have the patient blow his or her nose and save the tissue for radiological assay.

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4. Irrigate the nose with saline. Do this gently with the patient in a face forward position to prevent the patient from swallowing or aspirating the irrigating fluid.
5. To prevent contaminating the patient's mouth, protect it with a drape.
6. Clip and save nasal hairs if needed. Be careful not to damage mucosa.

Decontamination of the Eyes

Material may be deposited in the eyes by a splash or from airborne particles.

Procedures to Decontaminate the Eyes

1. If there are no contraindications, apply local anesthetic to the eyes.
2. Sample each eye separately with a moistened swab in conjunctival recesses.
3. Remove any foreign materials from the eyes and save them for radiological assay.
4. Irrigate medial to lateral with saline or ophthalmic irrigating solution to avoid irrigating contaminants into the lacrimal duct and the nose.
5. Protect skin and ear from contamination if appropriate.

Decontamination of the Ears

Material may be deposited in the ears by a splash or from airborne particles.

Procedures to Decontaminate the Ears

1. Sample each ear with a swab that has been moistened with saline.
2. Remove any foreign materials from the ears and save them for radiological assay.
3. Irrigate the ears with saline. Examine tympanic membrane for perforation in order to prevent irrigating contaminants into the middle ear.

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Decontamination of Wounds
Wounds can be received through blasts, lacerations, or crush.

Procedures to Decontaminate Wounds
1. Sample the wound with a swab or gauze using care to sample the extent of the wound.
2. Remove any foreign materials from the wound and save them for radiological assay.
3. Drape the entire circumference of the wound. Waterproof aperture drapes and plastic-backed pads (chux) work well. Drapes should be taped in place to form a waterproof covering to protect non-contaminated areas. Form drapes into a conduit in order to place irrigating fluid into a receptacle (barrel, basin, etc.). These irrigating fluids can be assayed to determine the radioisotope involved.
4. Decontaminate using the least aggressive method possible to prevent further damage. The usual methods are as follows:
   a. Irrigate with saline using standard irrigating procedures.
   b. Local debridement of contaminated or nonviable tissue.
   c. Surgical excision of contaminated tissue may be needed depending on the amount of contamination and the isotope involved, using sound risk/benefit decisions. This should only be done in consultation with the Idaho Radiation Control Program or other expert source.
5. Once wound care is completed, the wound should be covered with a waterproof dressing to prevent re-contamination.

Decontamination of Intact Skin
The skin can be contaminated through clothing, a splash, or from airborne particles. Decontamination of the intact skin is a relatively simple procedure. Complete decontamination is not always possible because some radioactive material can remain fixed on the skin surface. Decontamination should only be as thorough as is practical.

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Procedures to Decontaminate Intact Skin

1. Remove clothing. 80 to 90 percent of external contamination will be located on the clothing, so clothing removal will be highly effective. Clothing should be removed carefully so as not to spread the contaminants to the skin or the portals of entry. It should be carefully removed by rolling inside out to trap the contaminants within the rolled cloth. If clothing must be cut, it should be done carefully, and the clothing must be removed by rolling as stated above. The clothing should be placed in plastic bags that are tagged with the patient's identifying information and should be saved for radiological assay, even if ruined.
2. Sample the contaminated area with moistened gauze or swabs.
3. Isolate the area of contamination with waterproof drapes in the same manner as a wound to prevent spread to non-contaminated areas.
4. Use the least aggressive method. If intact, skin forms an effective barrier to most radioactive material. Any breaks in the skin greatly reduce this effectiveness and create a portal of entry. Overly aggressive decontamination efforts that result in damage to the skin must be avoided. Decontamination efforts should be stopped and reassessed if erythema or abrasions occur. The usual methods are as follows:
   a. Irrigate the skin with warm water.
   b. Irrigate the skin and gently scrub the skin with warm soapy water.
   c. Gently scrub the skin with a mildly abrasive soap, a paste made of detergent or cornmeal and water, or irrigate with diluted household bleach.
5. As with all other decontamination efforts, skin decontamination is a repetitive process. After each decontamination effort, the drapes are removed, the area surveyed, and a decision made regarding the need for further decontamination by the physician and RSO. Outside consultation may be required in difficult cases.

Decontamination of Hairy Areas

Hairy areas can be contaminated by clothing, a splash, or a cut.

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Procedures to Decontaminate Hairy Areas

1. Use a moistened swab to get a sample of the contaminated area, or cut a lock of hair as a sample.
2. Remove any foreign materials from the hair and save them for radiological assay.
3. Shampoo the hair.
4. If unacceptable contamination remains, remove contaminated hair by cutting. Hair should not be shaved, as shaving will cause small cuts and abrasions that can serve as a portal of entry. If shaving is needed for a surgical procedure, decisions will need to be made on a case-by-case basis.
5. Intact skin under the hair can be decontaminated following the procedures above.

TREATMENT OF INTERNALLY CONTAMINATED PATIENTS

Internal Contamination

Once internal contamination occurs, it will be more difficult to remove the radioactive material. Time is of the essence in the treatment of internal contamination because incorporation can occur rapidly with some isotopes. Once incorporation occurs, the isotope will be even more difficult to remove. Several methods exist to detect internal contamination, but these often require an extended period of time to accurately perform. Prompt treatment of an internally contaminated patient requires a high degree of suspicion based on the history, physical exam, contaminated portals of entry, and initial assays of samples obtained.

Treatment of internal contamination is a complex subject; expert consultation with the Idaho Radiation Control Program and the Radiation Emergency Assistance Center/Training Site (REAC/TS) should be obtained early. Decisions to begin empiric treatment for internal contamination will need to be made on a case-by-case basis with a careful risk/benefit analysis. Note: The Idaho Radiation Control Program can be reached by calling StateComm at (800) 632-8000. The REAC/TS 24-hour consultative service number is (865) 576-1005 (ask for REAC/TS). REAC/TS assistance, as well as other state and federal resources, can always be requested through StateComm.

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Methods of Internal Contamination Detection

To rapidly detect internal contamination/incorporation, check for one or more of the following:

- History of splash/spray, etc. with radioactive material.
- Contamination in or near portals of entry–mouth, nose, wounds, etc.
- Contamination found in emesis.
- Contamination found in urine. However, a negative urine sample does not rule out internal contamination.
- Contamination found in saliva.

Whole body counting can also be used to detect gamma-emitting isotopes inside the body. Whole body counting uses extremely sensitive detection equipment to determine the amount and type of radiation being emitted by the patient. From this information, the isotope and the amount of the radioactive material can be determined. The Idaho Radiation Control Program can arrange for whole body counting equipment.

Additionally, for those isotopes that are chemically toxic, symptoms of toxicity, such as heavy metal poisoning from uranium or plutonium, can also be detected.

Other methods are available for long-term detection of internal contamination or incorporation. Some of these methods involve collecting samples from the patient and placing them in a sensitive detection instrument where the amount and the identity of the isotope can be determined from the radiation being emitted. Samples collected for this type of analysis include:

- 24-hour urine and feces collections
- Repeat saliva collections

Treatment Measures—Internally Contaminated Patients

The most effective method of treatment is to prevent the internalization of the radioactive material. This can be accomplished through the effective, careful, and thorough removal of external contamination.

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The method of treatment depends, in part, on the isotope and its chemical nature. Due to the rapidity of incorporation or the toxicity of certain isotopes, treatment may need to be instituted based on suspicion of internal contamination. If this is being considered, the risk/benefit ratio must be weighed, and treatment started only if the possible benefits outweigh the potential risks involved.

Treatment Strategies—Internally Contaminated Patients

Below are four examples of basic treatment strategies that can be utilized to reduce the amount of time a radioisotope spends inside the body and reduce the risk of internalization of the radioisotope:

- Decrease absorption from gut
- Isotopic dilution
- Block incorporation
- Mobilizing agents

The treatment of internal contamination/incorporation is a complex subject, and early expert consultation is strongly recommended. The examples given here are meant to represent general guidelines. They do not constitute a complete listing of treatment options, and are not meant to constitute a treatment protocol or guide. Expert consultation is recommended.

Decrease Absorption from Gut

By decreasing the solubility of the radioisotope, the absorption of ingested radioactive material can be reduced, and the material passed with the stool. The use of a laxative may aid in this process and reduce the radiation dose to the gut by reducing the time the radioactive material spends in the gut.

- Gastric lavage and emetics can be used to remove materials from the stomach. However, lavage and emetics do not completely empty the stomach. On a similar note, lung lavage can be used to remove radionuclides deposited in the lung.
- Barium sulfate (oral contrast dye) can be used to form insoluble sulfates of strontium and radium, decreasing their absorption. The toxicity of barium sulfate is quite low, and it

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can be used immediately to prevent absorption. In addition, it is readily available in most hospitals.

- Aluminum and Magnesium salts (over the counter antacids like Mylanta™ and Maalox™) can be used to reduce absorption of isotopes such as radium and strontium. Like barium sulfate, these are non-toxic and readily available.
- Prussian Blue (not FDA approved) has been used for the removal of cesium from humans. It is not absorbed from the gut to any extent and can be used to increase elimination of cesium, thallium, and rubidium.
- PH adjustment can be used to change the solubility of some compounds. Alkalization will cause the formation of relatively insoluble hydroxides of metals such as iron and plutonium. Absorption of chromium, however, will be enhanced by alkalization.

Isotopic Dilution

Administering large amounts of a stable isotope of the same element as the radioisotope will increase excretion of the radioactive isotope. Isotopic dilution is used for isotopes such as tritium in the form of tritiated water. The excretion of the water containing tritium can be accelerated if the patient ingests large quantities of water, either through drinking or IV fluids. Diuretics may also be used if needed. Since the kidneys are unable to distinguish between tritiated water and stable water, the excretion of the tritiated water would increase along with the stable water.

Block Incorporation

Saturate the target tissue/organ with the stable isotope to reduce uptake of the radioisotope.

- Iodine-131 is the prototype for use. The patient is given a dose of stable iodine sufficient to saturate the thyroid (300 mg), thus effectively stopping the intake of iodine by the thyroid. In doing so, the thyroid would take up little or no radioactive iodine. The stable iodine must be given before or within about two hours of the exposure to be most effective. If delayed six hours, effectiveness is only about 50%, and there will be little effect if delayed 12 hours. The iodine should be

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continued at about 30 mg per day for one to two weeks to prevent re-absorption of any I-131 released by the thyroid. The kidneys would then excrete the radioactive iodine along with the excess stable iodine.

- Calcium can be used to block intake of radioactive strontium and calcium by bone, as well as increase urinary excretion. (Strontium will go to bone and be substituted for calcium).

Mobilizing Agents

Chemicals may be used to enhance elimination of the radioisotope from the body.

- Chelation. Chelating agents can be useful in some situations. Some of the radioisotopes (usually metals like copper, cadmium, manganese, etc. and heavy metals like plutonium, uranium, americium, etc.) are eliminated very slowly if at all by the kidneys. Chelating agents such as EDTA, DTPA, penacillamine, dimercaprol, etc. form compounds with the metals that are much easier for the kidneys to excrete, thereby increasing clearance from the body. During treatment, an increase in urinary excretion of the radioisotope should be observed. The chelating agents carry some toxicities of their own, and these need to be considered with the risk/benefits.
- Diuretics like furosemide can also be used to increase excretion of electrolytes such as sodium, potassium, chloride, etc. if the radioisotopes of these elements were involved.

Treatment Measures—Irradiated Patient

The ability to estimate the dose to which a patient has been exposed is important in the patient's care. It allows for the planning of care for the patient since some care may be extremely specialized and only available at tertiary care centers. It also allows for prognostication of the course and lethality of the exposure.

Dose Estimation

There are several methods available to estimate the dose of radiation to which a patient has been exposed:

- Dosimeter
- Clinical Effects
- Cytogenetic Dosimetry from REAC/TS
- Symptoms

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Dosimeter

Dosimeters can be used to record, to a high degree of accuracy, the dose a person received. They are obviously the best method for estimating the dose. This method, however, has a drawback; it requires that the patient wear a dosimeter at the time of the exposure. Dosimeters are normally only worn by persons who receive occupational exposure to ionizing radiation (e.g., nuclear power plant workers, x-ray technicians, etc.).

Clinical Effects

The absolute lymphocyte count (ALC) can also be used in dose estimation. Since the lymphocytes are the most radiosensitive of the circulating blood cells, the ALC at two days post exposure can be used as an early marker of lethality and exposure.

Absolute Lymphocyte Count (ALC) and Severity of Exposure	
ALC	**Severity of Exposure**
>1,500	Normal
1,000 - 1,500	Moderate
500 - 1,000	Severe
100 - 500	Very Severe
<100	Lethal

Cytogenetic Dosimetry

Radiation damages the DNA and chromosomes in the nucleus. It produces abnormal chromosomes in the process, including dicentrics, terminal deletions, translocations, ring chromosomes, etc. The circulating lymphocyte is the cell that is used. Blood is drawn as soon as possible after the exposure and the lymphocytes are forced into cell division chemically. The chromosomes are examined, and the frequency of chromosome abnormalities (usually dicentric chromosomes) is determined. This can then be correlated to the dose of radiation received. This method works best for

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uniform whole body exposures as the lymphocytes are constantly circulating. It would be impossible to determine which cells had been at the site of the exposure for a partial body exposure. Oak Ridge National Labs (REAC/TS) in Oak Ridge, Tennessee, can perform a special procedure to examine the chromosomes and estimate the frequency of chromosome abnormalities.

Symptoms

The rapidity of the onset of the symptoms of the prodrome and the magnitude of the symptoms correlate directly to the magnitude of the dose. For example, a person who develops nausea and vomiting within an hour of the exposure has likely received a high exposure. The person who develops a little nausea eight hours later has received a much lower dose. As the manifest illness stage is entered, the degree of signs and symptoms can also be used as a rough estimate of the dose and lethality.

As mentioned earlier, acute radiation syndrome is usually asymptomatic in the emergency department. If symptoms are seen, they will be nonspecific such as nausea, vomiting, etc. If no contraindications exist, patients can be provided with comfort measures such as antiemetics, IV fluids, analgesics, etc. as indicated during the prodrome. Initially, there is no specific treatment required for acute radiation syndrome. Extensive, complicated treatment becomes necessary as the manifest illness stage is entered and the damage is expressed.

TRANSFER FROM THE REA

Decontaminating the patient is just one step in the decontamination process. After decontamination, the patient and staff must also be prepared for exit from the contaminated area.

Patient Transfer from the REA

Use the following guidelines in preparing to discharge the **patient** from the REA.

1. After the patient has been decontaminated, perform a complete, head to toe body survey. Take swab samples of all previously contaminated areas. Place each swab in a container labeled with the patient's identifying information and mark as "post-decontamination" and indicate the exact area where they were collected.

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2. Replace gurney sheets with clean ones. Form a clean path from the patient to the control line by laying down clean floor coverings.
3. Bring a clean stretcher to the control line.
4. Place the patient on the stretcher with the help of clean attendants and wheel the patient to the door.
5. Have the RSO make a final check of the patient and the stretcher (especially the wheels) before moving the patient to other areas of the hospital.
6. After final approval, wheel the patient out of the REA and into the designated area.

Hospital Personnel Transfer from the REA

Use the following guidelines in preparing to discharge **hospital personnel** from the REA. Each member of the decontamination team goes to the control line and removes his or her protective clothing in the order described below:

1. Carefully 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 each foot while stepping over the control line.
8. Remove inner gloves.

After removal of PPE, a total-body contamination survey will need to be performed on each team member. After surveying "clean" take shower and redress in normal attire.

CLOSING OUT THE REA

Use the following guidelines in closing out the **REA**:

1. Secure the room until it can be decontaminated. If necessary, post a sign that says "CAUTION – RADIATION AREA."
2. Follow hospital or state procedures to decontaminate the area.

Check Your Understanding

1. Regarding the priority for treatment of a radiation accident victim, which of the following takes precedence?
   a. Conventional medical problems (pneumothorax, splenic injury)
   b. Radiological problems (radiation exposure or contamination)

2. List three reasons for performing decontamination.
   a. ______________________________
   b. ______________________________
   c. ______________________________

3. In a radiation incident, you may encounter three general classes of patients. These, either singularly or in combination, are:
   1) ______________________________
   2) ______________________________
   3) ______________________________

4. ________ tests are completed to assess the biological effects of radiation injury; to locate, identify, and quantify radionuclide contamination; and to provide information useful in accident analysis.

5. In general, 80 to 90 percent of external contamination will be located on the patient's __________.

6. Decreasing absorption from the gut, isotopic dilution, block incorporation, and use of mobilizing agents are treatment strategies that best apply to?
   a. Patients who have received a radiation dose of greater than 500 rem
   b. Patients who are externally contaminated
   c. Patients who are internally contaminated
   d. All of the above are correct

7. Cytogenetic dosimetry involves looking at the level of radiation-induced damage to the DNA and chromosomes in the nucleus and can be used as an indication of:
   a. The radiation dose received by the patient
   b. The level of contamination incorporation
   c. The effectiveness of external decontamination
   d. The buildup of radiation injury from previous doses

Idaho Transportation Emergency Preparedness Program

ANSWERS

1. a
2. see page 2
3. see page 4
4. labratory
5. clothing
6. c
7. a

ATTACHMENT 1

Clinical and Laboratory Assessments		
Samples Needed	**Why**	**How**
In all cases of radiation injury: Complete blood count and differential STAT (follow with absolute lymphocyte counts every 6 hours for 48 hours when history indicates possibility of total-body irradiation)	For radiation exposures, 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
Clothing	To assess for external contamination and to identify isotopes involved	Place clothing in sealed bags
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.
Swabs from wounds	Swabs from wounds	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
Skin wipes	To locate contaminated areas	Use filter paper, smear pads, or compresses to wipe sample areas 10 cm x 10 cm in size

ATTACHMENT 1 (CONTINUED)

Clinical and Laboratory Assessments, continued		
Samples Needed	**Why**	**How**
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	Body excreta may contain radionuclides if internal contamination has occurred	Save excreta in plastic containers in refrigerator or freezer
Vomitus	Body excreta may contain radionuclides if internal contamination has occurred	Save excreta in plastic containers in refrigerator or freezer
Sputum	To assess respiratory tract contamination if inhalation of contaminant was a possibility	Use five percent propylene-glycol aerosol to get a deep cough specimen - for radiation victims
Serum creatinine and BUN	To assess kidney function if chelation is indicated	Clinical chemistry
Other samples needed:		
All irrigating fluids	Radiological and hazardous materials assessment	Save in sealed and labeled, glass- or plastic-lined containers