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Information contained in this document was obtained from the following:

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RADIATION INCIDENT RESPONSE PLAN

INTRODUCTION

This plan outlines the procedures used by _____ to respond to individuals exposed to radioactive material both in our community, as well as within the facility. Coordination with the state and county Health Department will be necessary as the response of our facilities to these events will likely require public health direction.

In a **Mass Casualty Incident**, many people may come to a healthcare facility whether contaminated, injured or not. Most of the individuals who come to the hospital are likely to be ambulatory, minimally injured or concerned about potential contamination.

No medical care provider has ever been subjected to a medically significant level of radiation while caring for a patient of a radiologic accident/incident.

GENERAL GUIDELINES IN RESPONSE TO A RADIATION INCIDENT

A. Detection of Event

- Radiation can be easily detected, if suspected.
- Most hospitals have instrumentation available to detect commonly encountered sources of radiation (see Appendix A for common sources of radiation and Appendix B for relevant radiation detection instrumentation for healthcare facility responders).
- If an incident is unannounced, first detection may involve the symptoms of the patient(s) or be deduced through questioning of the patient(s)
- The FBI, with the assistance of the other federal and state health officials, will determine whether the event is terrorism related.

B. Events Which Could Cause Acute High Dose Radiation

- Misuse of high activity sealed sources used for medical or industrial purposes.
- Nuclear weapon detonation – blast zone survivors; extensive contamination.
- Accidents involving a nuclear reactor – initial planning limited to 10 mile radius – exposure and contamination to onsite personnel; potential release of radionuclides.
- Radiation Dispersal Device (RDD) – a relatively small number of individuals may receive higher doses due to imbedded shrapnel; contamination possible in immediate area of explosion and downwind; immediate psychological effects; acute radiation sickness unlikely.

C. General Classification of Radiation Incidents

Patients and staff could be exposed to radiation from different pathways:

External Exposure – In this scenario, an individual has been exposed to a source of radiation external to the body. The patient is not radioactive and staff does not become contaminated when dealing with the patient. Radiation injury may occur if the doses were sufficiently large. Appendix C provides a list of estimated absorbed doses required to cause deterministic or threshold-type effects following an acute exposure to radiation.

Contamination – Unwanted radioactivity residing in or on an individual. Radioactive contamination may be spread from person to person. Internal uptake occurs when contamination is inhaled, ingested or absorbed through an orifice, or wound. The majority of contamination can usually be eliminated by removing outer clothing. An individual *cannot* become contaminated due to exposure from an external source. Radiation dose from a contamination event is rarely life threatening.

Internal Uptake – Internal uptake refers to radioactive material that has been ingested, inhaled, absorbed or otherwise taken into the body. The dose to the individual will depend on the physical and chemical properties of the radionuclide(s) present. Urine and fecal specimens may be required to be collected in order to determine the radionuclide(s) present and their rate of elimination. An example of an internal uptake would be the inhalation of radioiodine and uptake in the thyroid gland. Generally, if internal uptake has occurred, contamination will also be present.

Most victims of a radiation incident will not demonstrate any signs or symptoms from radiation exposure. Similarly, staff exposure to radiation is expected to be much less than occupational exposure limits, i.e., 50 mSv/yr (5 rem/yr). In the catastrophic Chernobyl reactor incident in 1986, most medical personnel working on the victims received less than 10 mSv (1 rem).

D. Communications - Initial

Communication should focus on the hospital's response rather than the disaster itself. The healthcare facility should initiate and implement its disaster response plan. Communications between local hospitals and ambulance services will be facilitated through local emergency medical services communication systems. For example, some state agencies require 800 MHz radio communication with ambulances. The following procedure should be followed:

- External agencies will be notified at the direction of the healthcare facility's incident commander.
- The person(s) who are assigned responsibility for these notifications will document the following information for each call. These records will be forwarded to the incident commander.
 - a. the date/time of the call
 - b. the person(s) contacted
 - c. the basic information communicated
 - d. a summary of any response which is received

Internal Contacts:

Nursing Supervisor	_____
Administration	_____
Radiation Safety Officer	_____
Nuclear Medicine On-Call Technologist	_____
Communications/HR/Public Relations	_____
Medical Director	_____
Nuclear Medicine Physician	_____
Radiologist on call	_____

External Contacts:

_____ County Health Department	_____ (24 hr)
State Radiation Control Program	_____ (24 hr)

Area FBI Field Office

_____	County Emergency Coordinator	_____
_____	County Health Department Director,	_____
_____	County Health Dept. Incident Command Center	_____
_____	County Health Department Public Info Officer	_____
_____	County Emergency Operation Center	_____
State Health Department		_____
REAC/TS – medical assistance for radiation injuries		865-576-1005 (24 hr)
Medical Radiobiological Advisory Team (MRAT) – medical assistance for radiation injuries and uptake		301-295-0530 (24 hr)
HAZMAT National Response Center (Coast Guard)		800-424-8802 (24 hr)
Department of Energy		_____ (24 hr)
Nuclear Regulatory Commission (NRC)		_____ (24 hr)
Federal Emergency Management Agency		_____ (24 hr)
EPA Emergency Response Section,		_____ (24 hr)

- Local/state health departments may provide assistance in any of the following ways:
 - designating triage centers throughout the city
 - providing information to citizens via the media
 - transporting potentially exposed individuals requiring medical attention to area hospitals
 - requesting additional medical equipment from the national stockpile if required
 - forwarding updated information to health care professionals (e.g., “blast faxes”).

E. Healthcare Facility EOC Considerations

At the discretion of the healthcare facility Incident Commander, the facility Emergency Operations Center (EOC) will be activated. Consideration will be given to the necessity for the following measures; specific details for these measures are contained in subsequent sections of this Plan.

- the notification of the local and state health departments, FBI field office, local police, CDC, and/or medical emergency services and establishment of the type and scope of their support (section D)
- a facility lockdown (generally not a consideration for limited events, see section F)
- ventilation control procedures if outdoor threat exists (section G)
- the release of stable hospital patients who are not part of the event and/or the need to restrict admissions, as well as the transferring of victims to other facilities (section H)
- suggested medical supplies (section K)
- internal communications for staff, patients and/or visitors (section L)
- external communications with the media, other healthcare facilities and the community at large (section L)
- establishment of a decontamination area and procedures for decontamination of patients and the environment/equipment (section I)
- post-traumatic event counseling (section P)

F. Facility Lockdown

Securing and limiting the number of entrances into the healthcare facility, i.e., facility lockdown, may be necessary especially in a mass casualty incident involving a relatively large number of people. This may include road entrances as well as staff and visitor entrances. In general, a lockdown will be implemented if it is felt that there is a

risk that the unregulated arrival of persons seeking care from within the region will exceed the capabilities of the facility to safely deliver care.

- The healthcare facility Incident Commander, in collaboration with local/state health departments and law enforcement as needed, will determine whether there is a need for a facility lockdown.
- The Director of Security will be responsible for implementing and enforcing a facility lockdown and will request assistance from local law enforcement as needed.
- Communication for internal and external distribution will be directed by _____. Alternative sites for those seeking healthcare will be included in these communications.
- The authority for termination of a facility lockdown resides with the healthcare facility Incident Commander. The decision to terminate a lockdown will be made only after consultation with appropriate local/state health agencies.

G. Ventilation Control

- Upon direction of the healthcare facility Incident Commander, the Plant Operations/Facilities Supervisor will be contacted to consider shut down of the Heating, Ventilation, and Air Conditioning (HVAC) system in the affected area(s) or building(s) if any of the following conditions exist:
 - OUTDOOR THREATS: A local law enforcement or public health agency has announced a known or suspected release of airborne radioactive material in the area, such as might occur in a off-site release of radioactive material from a nuclear power plant.
 - Other conditions that are determined to involve a credible terrorist event.

H. Management of the Hospital's Patient Census

- If the number or type of hospital beds may be inadequate for anticipated needs, plan to assess the readiness of hospital patients for discharge; specify what, if any, restrictions will be needed for hospital admissions; determine if transfer of patients to other facilities will be necessary; and implement surge capacity plans.
- The Nursing Supervisor and Patient Care Directors will be responsible for activating and coordinating this portion of the healthcare facility disaster plan.

I. Patient Management and Decontamination

Patients exposed to ionizing radiation may include those who have received either an external whole body exposure, internal uptake or who have been contaminated. **The medical treatment of patients with significant injuries or medical conditions should always take precedence over decontamination procedures. Stabilization and resuscitation should take priority over decontamination.** The county should establish decontamination center(s) for the majority of potentially contaminated patients not requiring resuscitation and stabilization.

Whether injuries are life threatening or not, attempt to question the patient. Questions should include: when did the incident occur?, are hazardous chemical, biologic agents also involved?, **any recent nuclear medicine tests or radiation oncology procedures have been conducted recently?**, what post-event measures, if any, have already been taken such as use of blocking agents or isotopic dilution procedures?

1. Treatment of Patients Requiring Resuscitation and Stabilization:

If injuries require resuscitation and stabilization, immediately treat in the ED without regard to contamination. If possible, remove outer clothing and place clothing in a durable plastic bag with appropriate patient identifiers. If not, cover clothes to minimize contamination. Take care of wounds by irrigating, and covering to the best extent possible. Universal precautions and double gloving will protect ED staff from contamination. Survey hand and clothing with radiation survey meter and replace as necessary after each patient. If patient requires hospitalization, transfer to a clean gurney and wrap in a clean sheet. Provide containers for radioactive waste. Protect floor with covering if time permits. It may be desirable to designate a separate entrance for contaminated patients and transferring them to a clean gurney prior to entering the ED.

Samples taken from the patient such as blood or urine should be labeled with the patient's name, date, time of collection and "Caution Radioactive Material" tape obtained from Nuclear Medicine or the Radiation Safety Office before leaving the ED. **A summary of possible tests to be considered is listed in Appendix G.**

2. Treatment of Patients Suspected To Have Received a Large Dose of Radiation

Events causing exposure to a large dose of radiation are rare. Events such as nuclear weapons detonation or nuclear reactor core accidents may cause acute radiation syndrome (ARS). Exposure to smaller sources of radiation, such as teletherapy or industrial gauging devices could, over time, cause ARS. Depending on the dose received and amount of body exposed, prodromal symptoms can occur from hours to weeks later. In addition to the effects listed in Appendix C, a description of the symptoms caused by receiving large absorbed doses of radiation are listed in Appendix D and E. Based on the Chernobyl experience, a good predictor of survival is the time from exposure to vomiting. At Chernobyl, the majority of individuals surviving the event did NOT vomit within the first 2 hours post-exposure. This equated to an absorbed dose of approximately 4 Gy or less.

Lymphocyte count can be used to determine doses only if the total dose has exceeded several Gy (see Appendix F). Generally, if the lymphocytes have decreased by 50% AND are $< 1 \times 10^3 \text{ uL}^{-1}$ within 24 to 48 hours post-incident and no other medical conditions could have caused this decrease, the patient has received a moderate absorbed dose of radiation. A confounder in using lymphocyte counts to gauge absorbed dose includes patients with severe burns and/or trauma will also result in decreased lymphocyte counts.

For those individuals thought to have received large absorbed doses of radiation, i.e., $> 1 \text{ Gy}$, prolonged medical surveillance will be necessary. Conduct an initial CBC and every six hours thereafter for at least 48 hours. It will also be necessary to treat the patient antibiotics to prevent infections. Short term cytokine therapy may be appropriate when the absorbed dose is low, i.e., $< 3 \text{ Gy}$.

Absorbed doses in the range of 2 to 6 Gy are the most important for medical intervention. Individuals exposed to large absorbed doses of radiation > 2 Gy may exhibit the following symptoms:

- Nausea
- Vomiting
- Fatigue
- Weakness
- Psychological stress

It should be noted that all of these symptoms could be related to the anxiety of the event and should not be automatically associated with potential radiation exposure or contamination.

3. Treatment of Patients Suspected To Be Contaminated NOT REQUIRING Resuscitation and Stabilization:

Initial planning strategies for the decontamination of patients should include:

- Number of patients to be decontaminated over a specified period of time
- Source of tepid water, e.g., portable shower, permanent shower, sprinklers
- Climate, e.g., winter conditions, hot and humid conditions, strong winds
- Location of wet decontamination facilities in association with the ED
- Treatment of ambulatory and non-ambulatory patients

In an incident involving radioactive material, all patients presenting to the healthcare facility and not requiring resuscitation and stabilization should be considered contaminated until proven otherwise and wounds should be decontaminated prior to decontaminating intact skin. Wounds free of contamination should be covered with waterproof dressing to prevent cross-contamination. Patients who have no evidence of external contamination should be treated in a routine manner but patient specimens should be considered contaminated and labeled with the patient's name, date, time of collection and "Caution Radioactive Material" tape.

The following measures should be implemented for patient(s) presenting to the healthcare facility not requiring resuscitation and stabilization but who may be contaminated with radioactive material. The medical treatment of patients should always take precedence over decontamination procedures. Every effort should be made to explain the decontamination process, equipment used, patient specimens taken and contamination precautions to the patient *prior* to the start of any decontamination procedure.

- The decontamination area should be established in an area that will not impede regular traffic destined to the ED. **Only those individuals not requiring resuscitation and stabilization should be decontaminated prior to treatment.** A 'hot' patient entrance to the decontamination area should be established as well as a post-decontamination 'cold' zone. The decontamination area should be large enough to accommodate men and women as well as non-ambulatory patients not requiring critical medical care. Ideally, each should be assigned to separate decontamination lines. Non-ambulatory staff will require specialized convenience through the decontamination area. An area to take patient vital signs as well as treat minor injuries should be set up in the cold zone.

- If radioactive contamination is suspected, the Operator will contact decontamination team members, the Radiation Safety Officer and the nuclear medicine technologist-on-call immediately.
- Security will assist in directing traffic to and around the decontamination area. They will also assist in directing the more critically injured to the ED.
- Decontamination team members should obtain Geiger Mueller (GM) meter from Radiation Safety Office, Nuclear Medicine or Radiation Oncology. Individuals familiar with the use of radiation instrumentation such as the Radiation Safety Officer, physicists or Nuclear Medicine staff should be consulted. Perform a battery check and determine if the instrument is functioning properly by using an embedded check source or a nuclear medicine dose. Cover probe with latex or nitrile glove to prevent contamination.
- **Clearly identify triage and decontamination stations.** Use radiation instrumentation such as a GM meter to screen for the presence of radiation which will allow separation of non-contaminated patients, which can be treated in the usual manner, from those requiring decontamination. Radiation screening devices such as portal monitors used to screen healthcare facility waste are attractive in attempting to deal with large numbers of potentially contaminated individuals. However, as of January 2006, no national manufacturing standard had been established for portal monitors. In addition, many existing portal monitors are not wide enough to accommodate wheel chairs or gurneys and all require periodic calibration and testing.
- The decontamination area should be clearly identified either with highly visible tape or traffic cones. No personnel are to enter this zone without first donning the appropriate level of personal protective equipment (PPE), e.g., PAPR, gloves, and boots. All individuals shall have received appropriate training and medical screening necessary for using PPE (see Appendix H). Protective clothing will also stop alpha and some beta particles.
- If individual is contaminated or potentially contaminated, remove outer clothing. This eliminates 70 to 90% of the contamination. Careful removal of contaminated clothing and decontamination of patients minimizes the potential for personnel contamination. Use privacy screens. If screens aren't available, use bed sheets. Bag, label and hold contaminated clothing and other contaminated items for Radiation Safety Officer. The bag should be clearly marked 'Do Not Discard' or similar verbiage. Provide a secure area to store the bagged articles.
- After outer clothing has been removed, instruct person to stand straight, feet slightly spread, arms extended with palms up and fingers straight out. **Start at the top of the head and work downward.** Pay particular attention to the hands. Scan slowly (about several inches per second) within an inch or so of the person's skin. Be careful not to touch the probe to potentially contaminated surfaces. Monitor carefully the forehead, nose, mouth, neckline, torso, knees and ankles. Repeat this technique with the back of the body. Monitor soles of the feet. Decontaminate individuals using soap and tepid water. Do NOT scrub aggressively or use a hard bristled brush. This will potentially allow radioactive contamination to be absorbed through the skin. Thermal burns should

NOT be scrubbed due to the danger of hypothermia and hypotension and further risk of injury to the skin. Scrubbing abrades and removes marginally viable skin, increases blood flow to the affected area and can increase dermal absorption of contaminants. Only gentle rinsing should be employed. Potentially harmful practices, such as bathing patients with bleach solutions are unnecessary and should be avoided. Clean water, saline solution or commercial ophthalmic solutions are recommended for rinsing the eyes. Contamination found in the hair and not easily removed should be cut with a scissors. Instruct the patients NOT to swallow any water. Decontamination should be performed until removable contamination is less than several times background (for a GM meter with pancake probe, this would be approximately 200-300 cpm) or until no more contamination can be removed. Isolate and cover any area of the skin that is still above background. **Periodically check the background level of radiation in an area. Elevated background levels can occur if the radiation detection instrument becomes contaminated or if radioactive material is accumulating in the scanning area.**

- Decontamination should be performed with the following priorities:
 - Wounds

Contaminated wounds are first draped, preferably with a waterproof material to limit the spread of radioactivity. Contaminated wounds are to be cleaned by gentle scrubbing with a surgical sponge and irrigation. If area still has a highly elevated count rate, conventional debridement of the wound must be considered but only after consultation with medical staff with expertise in radiation wound management, e.g., REAC/TS. Remove contaminated drapes, dressings, etc., and monitor with GM meter probe covered with latex or nitrile glove. Place in a bag and label bag as radioactive.
 - Orifices

Contaminated body orifices, such as the mouth, nose, eyes and ears need special attention because of possible rapid absorption. If time permits, use moistened swabs and collect a sample of each orifice separately. Bag (e.g. in a labeled “zip-lock baggie”) separately and save for assay for internal contamination. Generally, it is estimated that nasal swab activity represents approximately 5% of lung deposition. If radioactive material has entered the oral cavity, encourage brushing the teeth with toothpaste and frequent rinsing of the mouth. Instruct the patient NOT to swallow. If the pharyngeal region is also contaminated, gargling with a 3% hydrogen peroxide solution might be helpful. Contaminated eyes should be rinsed by directing a stream of water or ophthalmic solution 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.
 - Skin decontamination

Complete decontamination is usually not possible because some radioactive material remains fixed to the skin. Decontamination to twice background levels is usually sufficient. Decontamination should be stopped if no further decrease is noted. Remember to assess the background radiation level *before* the contaminated patient arrives.

Ensure the radioactive contamination results, usually in counts per minute (cpm), identified at the various locations on the body, are recorded in the patient's chart.

- Periodically check the background level of radiation in an area. Elevated background levels can occur if the radiation detection instrument becomes contaminated or if radioactive material is accumulating in the scanning area.
- Decontamination team members or other personnel with specialized radiation safety expertise should survey all personnel leaving the hot zone with a GM meter with special emphasis on the hands and feet.
- All staff involved with patient triage or decontamination should wash their hands thoroughly before leaving the area.

4. “Worried Well”

In an MCI event, a number of individuals reporting to the healthcare facility will likely be absent of any clinical symptoms of acute exposure to radiation. Many will present before more seriously injured victims appear at the healthcare facility. For this reason, effective disaster response plans including triage procedures must be in place **prior** to an event. In many cases involving a radiation incident, members of the general public may request antibiotic, vaccines or radiation protectants such as potassium iodide (KI) from their physicians. Giving antibiotics to otherwise “well” patients may reduce the supply to patients who actually need the medications. KI is a specific agent intended to reduce internal uptake of radioiodine but is NOT a general ‘antidote for radiation’. **A list of drugs which can reduce either uptake or absorbed dose can be found in Section J.**

5. Patients Later Found To Be Exposed or Contaminated

In a situation where patients have been treated in the ED or hospital, released and later found to have been exposed to either external radiation or may have been contaminated, the Radiation Safety Officer should be immediately notified. If contamination is suspected, the Radiation Safety Officer will survey all areas known to have been visited by the patient and perform any necessary decontamination. If it is determined a discharged patient may have been exposed to a large dose of radiation prior to their arrival at the hospital, a physician familiar with the biological effects of radiation should contact the patient's primary care physician to discuss possible long-term effects and follow-up.

J. Radiation Protectants (Currently Approved by FDA as of March 2006)

If internal uptake is suspected, several options are available to limit internal uptake. *These medications should not be taken without consultation with physicians familiar with their usage.*

Limit Uptake

Radioiodines, e.g., ¹³¹I, ¹³⁴I, ¹²⁵I

For suspected radioiodine internal uptake, prescribe KI if within 12 hours. Tablets of KI are available over-the-counter. 130 mg of KI (65 mg for infants) effectively blocks 100% of the thyroid uptake of radioiodine **if** given prior to the event. KI given 4 hours post-uptake minimizes thyroid uptake by approximately 50%. KI given 12 hours post-uptake has little effect. Contraindications include individuals allergic to iodine. KI should not be given to individuals with dermatitis herpetiformis and

hypocomplementemic vasculitis. Individuals with multinodular goiter, Graves disease, and autoimmune thyroiditis should be treated with caution especially if dosing extends beyond a few days. Unless extreme conditions warrant, repeat dosing with KI is not recommended for pregnant females and neonates. **KI does not protect organs other than the thyroid.**

Radiocesium, e.g., ¹³⁷Cs, ¹³⁴Cs

Radiothallium, e.g., ²⁰⁴Tl, ²⁰¹Tl

Insoluble Prussian Blue, sold by Heyl Chemisch-pharmazeutische Fabrik GmbH under the trade name, Radiogardase-Cs, enhances excretion of isotopes of cesium and thallium from the body by means of ion exchange. It was approved by the FDA in 2003 for oral administration to treat internal cesium and thallium contamination. Orally administered Prussian Blue traps cesium and thallium in the gut, interrupts its resorption from the GI tract and thereby increases fecal excretion. It reduces the effective half life of the material in the body by approximately 50%. It is still effective if given several days after intake. The prescribed dose will depend on the level of suspected internal contamination. All administrations should be TID. This drug is effective only if GI motility is intact. Concomitant administration of tetracycline may retard absorption of Prussian Blue. Pregnant and lactating women are able to tolerate this compound. Because potassium, chemically similar to cesium, could also be absorbed, electrolyte levels should also be monitored.

Transuranic Elements, i.e., plutonium, americium, californium and curium

Recently the FDA approved the use of Ca-DTPA and Zn-DTPA for the treatment of internal contamination by plutonium, americium, californium and curium transuranic soluble salts. DTPA is a chelating agent and exchanges either calcium or zinc for another metal with greater binding ability and carries it to the kidneys where it is excreted in the urine. The chelating efficacy is greatest immediately, or within one hour, following uptake when the radionuclide is circulating in or available to tissue fluids and plasma. Ca-DTPA is approximately 10 times more effective within the first 24 hours than Zn-DTPA for chelation of transuranics and therefore should be used whenever larger body burdens are expected. However, after 24 hours, Zn-DTPA is as effective as Ca-DTPA and should be used for protracted therapy because of its lesser toxicity. Zn-DTPA is recommended for sensitive populations such as children, pregnant women, and patients with known kidney disease or bone marrow suppression. Ca-DTPA or Zn-DTPA should be administered either by slow intravenous push over a period of 3 to 4 minutes; intravenous infusion or inhalation in a nebulizer. Follow-up and additional therapy may be continued for years if necessary. DTPA chelating agents are manufactured by Hamelin Pharmaceuticals in Germany. **DTPA should not be used for uranium or neptunium internal uptake.**

Strontium

Over-the-counter antacids reduce gastrointestinal absorption of strontium. Aluminum containing antacids are the most effect, reducing strontium uptake by 50 to 85%.

Uranium

Generally, uranium presents a greater chemical than radiologic hazard. Alkalize the patient with sodium bicarbonate in order to promote excretion. Alkaline urine forms a non-toxic uranium carbonate complex that is promptly excreted through the kidneys. Important factors in determining the effectiveness of this method include the chemical form and particle size of the inhaled uranium. Sodium bicarbonate should be administered either orally or intravenously.

K. Required Supplies

Suggested supplies needed inside the healthcare facility to treat potentially contaminated or patients receiving large absorbed doses include:

- Gowns
- Surgical scrub suits
- Surgical masks
- Surgical caps
- Disposable shoe covers
- Double non-sterile gloves with outer glove removed after each contact
- Disposable non-sterile gloves or Saran Wrap to cover and protect instruments
- Absorbent paper to cover the floor (may not be feasible for large scale event)
- Adhesive tape
- Personal dosimeters (electronic is best) for staff frequently in contact with contaminated patients
- Multiple portable survey instruments such as GM meters. Instruments should be properly calibrated
- KI tablets
- CBC tubes (purple tops which contain EDTA preservative)
- Filter paper, swabs and collection tubes
- "Caution Radioactive Material" tape

L. Communication – Medical Staff and Patients

Communication provided to the staff should be frequent and accurate. Address fear of radiation and contamination concerns. Anxiety symptoms include vomiting, diarrhea, nausea and headaches – the same symptoms caused by acute radiation exposure.

Patient information should include accurate information on the acute and long term health consequences of radiation exposure and should be included in the discharge instructions. Fact sheets and Q&A sheets could also be given to patients. Fact sheets should include subject matter expert contacts and reliable sources of information. The information should be brief and easy to understand.

Following an incident or drill, conduct a tiered critique (physician staff separate from allied staff separate from housekeeping etc) and report findings to the hospital board or other appropriate committee or group.

In the event of a radiation incident, the following actions should be followed:

- ___(Fill in Position Title)___ will develop appropriate and timely communications for hospital and clinic staff, community medical staff, patients, visitors, the media and the community at large.
- Consider whether a media center, preferably located outside of the facility, should be established. Multiple power, telephone and computer lines as well as fax capability will be required in the media center.
- Consider establishing staff and visitor telephone communication lines. These lines should be updated frequently with estimates given for the next update. Patient lists should be maintained for inquiring family members. This information should also be coordinated with the local county health officials.
- All communications will be reviewed and approved by ___(Fill in Position Title)___ prior to distribution

M. Laboratory Support

Specimens recommended to be collected by REAC/TS in a radiological event include blood, urine, feces, nasal and saliva swabs, sputum, vomitus and wound secretions (see Appendix G). All specimens should be considered radioactive until proven otherwise. Differential complete blood counts (CBCs), taken over several days, are used to establish baseline and assess radiation dose received. If acute radiation syndrome is possible, CBC's should be repeated every 6 hours for about 48 hours. Hospitals should identify, during planning, state agencies or labs able to receive samples for analysis. Often, Nuclear Medicine departments will have thyroid probes with NaI gamma spectroscopy capability and research sites will have liquid scintillation detectors that can be used for beta and low energy gamma detection. The use of these instruments for quantitative analysis however is limited by proper calibration for the various source counting configurations.

N. Training

The Radiation Emergency Assistance Center/Training Site (REAC/TS), operating out of Oak Ridge Institute for Science and Education in Tennessee, has provided guidance for radiation accident management on its website (<http://www.orise.orau.gov/reacts/guide/index.htm>)
Video demonstrations include

- Dressing to prevent the spread of radioactive contamination
- Preparing a patient treatment area
- Removing contaminated clothing
- Surveying for radioactive contamination
- Decontaminating a wound
- Decontaminating intact skin

At a minimum, ED and Primary Care physicians and ED staff should receive awareness level training in the above listed topics. Updated information will be provided through the Radiation Safety Officer.

Occupational Safety & Health Administration (OSHA) requires Operations level training for personnel expected to treat, triage or decontaminate victims or handle victims before they have been completely decontaminated. This training must be 8 hours in duration and healthcare organizations must document on how these requirements are met (see Appendix H). Annual refresher training is also required.

The CDC website has training material for ED staff. Also, the Health Physics Society Medical Response website has PowerPoint presentations that can be used for hospital staff training.

O. Post-Mortem Considerations

All autopsies involving victims of potential terrorist events will be referred to the Medical Examiner for examination; they will not be performed on site. Funeral directors will be provided safe handling instructions, as indicated by the diagnosis/suspected disease for these bodies by the Pathology Department in cooperation with Infection Control or Radiation Safety.

P. Post-Traumatic Event Counseling

Radiation counseling should be conducted in the presence of the Radiation Safety Officer or board certified physicists as well as trained counselors. Possible discussion items should include:

- Short term acute effects
- Long term cancer risks
- Genetic risks
- Fetal risks

Most people will exhibit higher levels of anxiety rather than psychotic behavior. Some will also experience Post Traumatic Stress Disorder. Long term psychological effects could start arising 48 to 72 hours after the incident and continue for several months. Be proactive in reassurance and communication to reduce psychological issues. Information should be consistent with fact sheets and other information distributed to patients.

Appendix A

Sources of Radiation (adopted from ACR, 2005)

Naturally Occurring Radioactive Material (NORM) – typically <1% of any element occurs naturally as radioactive; may cause harm if concentrated

Ex – ^{226}Ra , ^{40}K , ^{210}Pb , ^{234}U , ^{235}U , ^{238}U

Nuclear Fuel Cycle – the series of steps through which nuclear fuel passes

- Mining and Milling
e.g., ^{235}U and its radioactive decay products; ^{238}U and its radioactive decay products; ^{222}Rn
- Conversion
e.g., same as above
- Enrichment
e.g., enriched ^{235}U and its radioactive decay products; depleted ^{238}U waste
- Fuel Fabrication
e.g., ^{235}U and its radioactive decay products; ^{238}U and its radioactive decay products; ^{222}Rn and its radioactive decay products; isotopes of Pu
- Byproducts of nuclear power generation
Isotopes from above processes plus fission products
Fission products include:
Gases – ^3H ; Kr isotopes; Xe isotopes
Solids – ^{88}Rb ; Sr isotopes, I isotopes; Cs isotopes; neutron activation products (^{51}Cr , N, Co, Mg isotopes, ^{41}Ar)

Isotopes Used in Medicine

- Nuclear Medicine – Most often involves small quantities of liquid or capsular radiation, i.e., < 1.1 GBq (30 mCi), used for diagnostic exams. Could also include therapeutic quantities of radioactive material, i.e., > 3.7 GBq (100 mCi), used to treat cancer.
e.g., $^{99\text{m}}\text{Tc}$; ^{131}I , ^{201}Tl
- Radiation Oncology – Sealed sources of radiation used to treat cancer. Tend to be larger activity sources, i.e., 370 MBq to greater than 37 TBq (10 mCi to 1000's of curies), and therefore, are of greater concern.
e.g., ^{60}Co , ^{137}Cs , ^{192}Ir , ^{125}I , ^{103}Pd
- Biomedical research – Small quantities of liquid radioactive material are commonly used as biomarkers in research. Documented cases have occurred where individuals have introduced this material into co-workers foodstuffs. Involves small activity, typically liquid, sources, i.e., < 370 MBq (10 mCi).
e.g., ^{14}C , ^3H , ^{125}I , ^{32}P , ^{35}S , ^{51}Cr , ^{33}P

Sources Used In Military

- Projectile rounds – depleted U, ^3H
- Luminous paint – ^{147}Pm , ^{226}Ra
- Soil density monitor – ^{241}Am , ^{137}Cs
- Chemical agent monitor – ^{241}Am , ^{63}Ni

Sources Used in Industry

- Exit signs – ^3H (up to 777 GBq (21 Ci) each)

- Specimen dating – ^{14}C – small quantities, i.e., < 37 MBq (1 mCi)
- Smoke detectors – ^{241}Am – small quantities, 37 kBq (1 μCi) per device
- Industrial radiography – ^{192}Ir , ^{60}Co – device contains relatively large quantities of sealed sources of radiation; 0.2 to 7.4 TBq (5-200 Ci).
- Food irradiation and sterilization – ^{60}Co , ^{192}Ir – large quantity sealed sources of radiation; up to 10's to hundreds of TBq (1000's of curies).
- Gauges – ^{241}Am , ^{137}Cs , ^{60}Co , ^{90}Sr – sealed sources of radiation
- Neutron Soil Density Monitor – $^{241}\text{Am/Be}$ – sealed sources of radiation; up through 1 GBq (10's of mCi's).
- Well Logging Devices – ^{137}Cs , ^{241}Am - sealed sources of radiation; 37 to 850 GBq (1 to 23 Ci)

Appendix B

Radiation Detection Instrumentation for Healthcare Facility Responders			
<i>Detector Type</i>	<i>Application</i>	<i>Radiation Detected and relative detection efficiency</i>	<i>Remarks</i>
GM (<2.0 mg/cm ² window thickness)	Detecting the presence of radiation. Typically used to scan patients for contamination. Can be purchased with or without detachable probe	Alpha (highly dependent on detector window thickness and distance from source) Beta (energy dependent): 5% ^{14}C ; 32% ^{32}P Gamma: <1%	Very rugged and dependable. Energy dependent and not recommended for measuring dose rate unless the meter has been calibrated for the isotope(s) in question. May become saturated at very high count rates and appear not to detect the presence of radiation.
GM – energy compensated	Used to measure dose rate and/or accumulated dose	+/- 20% of true value (typical) for gamma emitters (60 keV to 1.3 MeV)	Able to provide dose rate or accumulated dose information in widely varying temperature and humidity conditions.
Nal	Detecting the presence of gamma radiation. Typically used to scan patients for contamination.	Low energy gamma emitters - thin window Nal (typically 1 mm) low energy gamma emitters (approximately 10-60 keV): 19% ^{125}I High energy gamma emitters – 1" x 1" or 2" X 2" thick: maximum sensitivity around 100-120 keV	High sensitivity; energy dependent; may be less effective in high background conditions. Shock sensitive and should not be dropped on a hard surface
Ion chamber (1 to 7 mg/cm ² window)	Establishing dose rate estimates for gamma and bremsstrahlung from energetic beta emitters	Energy independent	Readings may be influenced by environmental conditions
Electronic dosimeter (contains energy compensated GM tube)	Monitoring accumulated radiation dose for medical staff	Energy independent (see information on 'GM – energy compensated')	Can provide instantaneous accumulated dose information

Appendix C

Estimated Threshold Absorbed Doses for Deterministic Radiation Effects Following an Acute Exposure To Low-LET Radiation (adopted from NCRP 138, Table 4.1)

Effect	Critical Organ	Threshold Dose, Gy	Time Until Expression of Effect
Temporary sterility	Testis	0.15	
Nausea		0.35	
Depression of blood cell forming process	Bone marrow	0.5	See Appendix E
Cataracts	Lens of eye	2.0 for single dose	8 yrs (2.5 to 6.5Gy)
Early skin erythema (temporary)	Skin	2.0	2 to 24 hours
Permanent sterility	Ovaries	2.5 to 6	
Vomiting		3.0	
Epilation (temporary)	Skin	3 to 5	3 weeks
Permanent sterility	Testis	3.5	
Main erythema	Skin	6	10 days
Epilation (permanent)	Skin	6 to 7	3 weeks

Appendix D

Effects of Large Acute Doses of Radiation

Acute Dose, Gy*

Effect

3.3 to 4.0	Whole body dose lethal to 50% of individuals within 60 days of exposure with minimal supportive care
6 to 7	Whole body dose lethal to 50% of individuals within 60 days of exposure with supportive medical treatment
2 to 8	Loss of blood-forming stem cells Symptoms: chills, ulceration of the mouth, hair loss Death may occur several weeks after exposure from larger doses
8 to 30	Loss of GI mucosal stem cells Symptoms: bloody diarrhea, severe nausea, vomiting Death occurs in a number of days to several weeks
>30	Cascading collapse of a number of systems required to sustain life Symptoms: nausea and vomiting within minutes, disorientation, loss of muscular movement, cardiovascular shock Death occurs in hours to days

* Dose is approximate and symptoms will vary from individual to individual

Appendix E

Ranges for Significant Effects from Nuclear Explosion (NCRP 138 Table 3.7)

Yield K,T	Range of 50% Mortality from Air Blast m	Range for 50% Mortality from Thermal Burns m	Range for 4 Gy Initial Nuclear Radiation m	Range for 4 Gy Fallout in First Hour After Blast* m
0.01	60	60	250	1,270
0.1	130	200	460	2,750
1.0	275	610	790	5,500
10.0	590	1,800	1,200	9,600

* Note: Fallout depends on such factors as air or ground burst, wind speed, precipitation

Appendix F

Lymphocyte Count in Humans at 24 to 48 Hours Post Exposure to Radiation (NCRP 138 Table 4.3)

Lymphocyte Count ($10^3 \mu\text{L}^{-1}$)*	Absorbed Dose (Gy)	Lethality Without Medical Treatment (%)
3	0 to 0.25	Minimal
1.2 to 2	1 to 2	<5
0.4 to 1.2	2 to 3.5	<50
0.1 to 1.2	3.5 to 5	50 to 99
0 to 0.1	> 5.5	99-100

*Note: Patients with severe burns and/or trauma to one or more systems will experience decreased lymphocytes in the absence of acute radiation exposure.

Appendix G

Patient Specimens To Be Collected In a Radiation Incident (ORAU REAC/TS)

FOR ALL SUSPECTED RADIATION CASES

Samples Needed

CBC and differential STAT followed with absolute lymphocyte counts every 6 hours for 48 hours when history indicates possibility of whole body irradiation.

Rationale

Needed to access dose. Initial counts establish a baseline, subsequent counts reflect the degree of injury.

Collection Methodology

Choose non-contaminated area for venipuncture. Verify using GM meter. Cover site after collection.

Routine urinalysis

To determine if kidneys are functioning normally and to establish a baseline of urinary constituents; especially important if internal contamination is likely.

Collect in urine container labeled with patient name, date and time. Wear gloves and avoid contaminating specimen during collection.

FOR EXTERNALLY CONTAMINATED RADIATION CASES

Samples Needed

Swabs from body orifices

Rationale

Assess possibility of internal contamination.

Collection Methodology

Use separate saline- or water-moistened swabs to wipe nostrils, ears mouth, etc.

Wound dressings

To determine if wounds are contaminated.

Save dressings in a plastic zip lock bag labeled with patient name, date and time. Use moistened or dry swabs to sample secretions from each dressing.

FOR SUSPECTED INTERNAL RADIATION UPTAKE CASES

Samples Needed

Urine: 24 hour specimen collected for four consecutive days

Rationale

Body excreta may contain radionuclides if internal contamination has occurred.

Collection Methodology

Use 24-hour urine collection container. Wear gloves when handling specimen.

Feces: collected for four consecutive days

Body excreta may contain radionuclides if internal contamination has occurred.

Use 24-hour urine collection container. Wear gloves when handling specimen.

Appendix H

OSHA Operations Level Training Documentation Requirements

Must have documented competency at the Awareness level.

Verbalize an understanding of the hospital emergency response plan and their roles in this plan and risks to receiving personnel.

Verbalize when PPE is required.

Verbalize the limitations of PPE.

Verbalize the proper care, maintenance, useful life and proper disposal of PPE, decontamination equipment and related supplies.

Verbalize the nature of the potential respiratory hazard and reasons for a respirator.

Verbalize respirator capabilities, limitations and consequences if the respirator is not used properly.

Verbalize how to handle respirator malfunctions and other emergencies.

Verbalize how to recognize medical indications that may limit or prevent effective use of a respirator.

Verbalize when to change cartridges and or/ batteries on PAPR's.

Verbalize the proper maintenance and storage procedures for respiratory protection equipment.

Verbalize the general provisions of the healthcare facilities respiratory protection program

Verbalize and demonstrate appropriate selection of PPE.

Verbalize and demonstrate proper decontamination procedures for ambulatory and non-ambulatory patients.

Demonstrate how to properly don, adjust and remove PPE. Staff must be able to demonstrate competency in wearing all PPE including respirator, protective garments, gloves and boots.

Demonstrate proper setup and use of all decontamination-related equipment and supplies