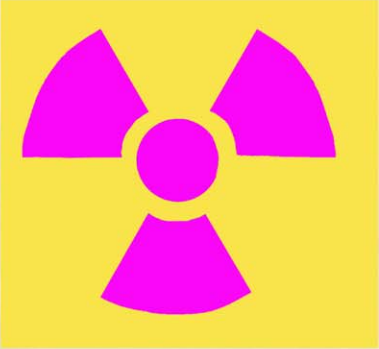
State of Illinois
Illinois Emergency Management Agency

Radiation Accidents

Guide for Medical Professionals on Handling, Transporting, Evaluating and Treating Patients Accidently Exposed to Radiation or Contaminated with Radioactive Materials



IEMA

September 2007

IEMA
Illinois Emergency Management Agency

Rod R. Blagojevich, Governor
Andrew Velasquez III, Director

September 2007

This guide is intended for the informational use of emergency medical personnel in Illinois who may be upon to deal with a situation in which an individual has been accidentally exposed to radiation.

There are 11 commercial nuclear reactors licensed to generate electricity in Illinois, as well as a number of research facilities, firms that manufacture or process radioactive materials, and thousands of radiation-producing machines used in medical and industrial applications. In addition, radioactive materials and waste shipments are routinely and safely transported within and through the state. All of these activities are tightly regulated and closely monitored, but the potential remains that an individual might be exposed or contaminated as a result of an accident or a deliberate act of terrorism.

The Illinois Emergency Management Agency has developed this guide to help hospital emergency room staff and emergency medical services personnel better understand how to deal effectively with the victim of radiological exposure.

I urge you to familiarize yourself with this material and to contact this agency if you have questions, need assistance or desire additional information or training in this area.

Sincerely,

Andrew Velasquez III
Director

1035 Outer Park Drive • Springfield, Illinois 62704-4462 • Telephone: (217)785-9900
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PREFACE

Responding to requests from hospitals and ambulance service providers throughout the state, this guide was initially developed in 1995 with the assistance of medical experts from a number of organizations, including Loyola University, the Oak Ridge Associated Universities, and the Illinois Department of Public Health.

The Guide recognizes that the provision of emergency medical services is an integrated process, and that both hospital and Emergency Medical Services (EMS) personnel need to understand the specialized protocols that should be observed in handling and treating radiation accident victims in order to deal effectively with the patient's condition as well as minimizing the potential for exposure and the unnecessary spread of contamination.

Specific information relevant to the accident scene and transport activities by EMS personnel and those evaluation and treatment functions anticipated in a hospital emergency room setting are separated within the Guide for easier reference.

The material in this publication is intended for informational use only. It is not represented as definitive diagnostic or clinical instruction. Before directing specific treatment protocols, advice should be obtained from a qualified professional with experience in diagnosing and treating radiation-related illnesses. Some sources of such advice are listed in the Resource section of the Guide.

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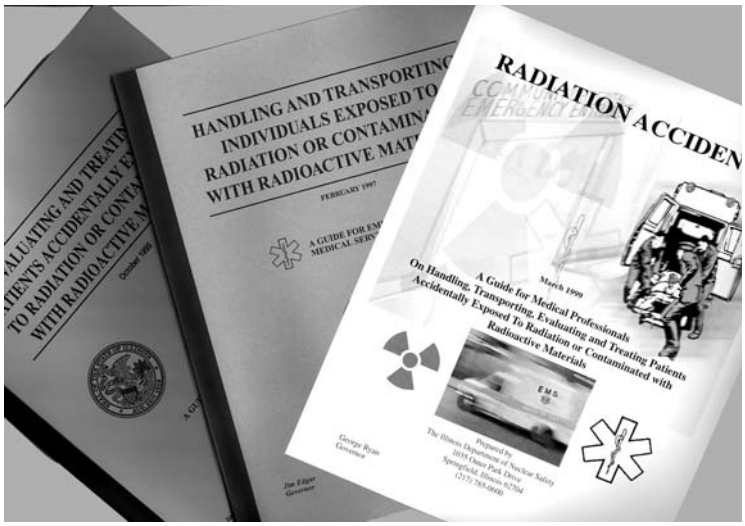
We hope you find this document helpful. Your questions and comments are welcome. Please direct them to the Disaster Assistance and Preparedness Bureau, at 1035 Outer Park Drive, Springfield, IL 62704
or call (217)-785-9882.



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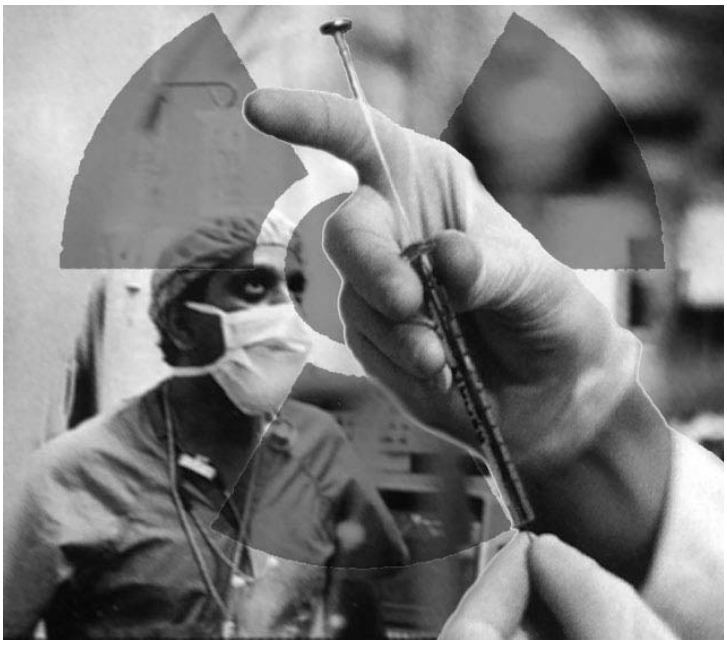
OVERVIEW

The objective of this publication is to offer general guidance in the handling of patients with typical injuries complicated by the presence of radioactive contamination, and patients suspected of having been exposed to elevated levels of radiation.

Radiation injury has been an infrequent occurrence in our society. However, as careful as we may be, with the increasing use of industrial radiography sources, and with localized areas of high radiation within nuclear facilities, the possibility that an individual will be exposed to excessive radiation at some point in time cannot be overlooked. The handling of radioactive materials in a wide variety of situations also increases the potential for contamination associated with many types of common industrial and transportation accidents. And, unfortunately, there is always the potential for deliberate misuse of radioactive material.

It is highly unlikely that most health care providers will ever encounter a patient who has been exposed to levels of radiation that pose an immediate threat to life. However, the expanding use of radioactive materials in medicine, science, and industry have significantly increased the potential that under emergency conditions the medical professional may be presented with a patient who has been contaminated or exposed to low-level radiation. Dealing effectively with known or suspected contamination, and accurately assessing the potential exposure, can avoid long-term health problems for the patient.



This guide explains the practical aspects of handling the contaminated and/or exposed patient in an emergency situation, including recommendations on the precautions that should be observed in dealing with such cases. It also includes important information on the respective roles of EMS personnel and hospital emergency room staff in handling an individual contaminated with radioactive material.

Part One provides an overview of the kinds of radiation accidents that can produce a contaminated or exposed victim, and explores some of the basic concepts involved in understanding how these situations differ from other hazardous materials incidents.

Part Two addresses issues that EMS, ambulance and rescue personnel should consider when confronted with a situation involving a radiologically contaminated or exposed victim.

Part Three is intended for use by physicians and other hospital staff assigned to evaluate and treat the patient who is known to be or suspected of being contaminated or exposed. It deals with the effects of exposure, and contains information on etiology, clinical

manifestations, and classifications of severe radiological injuries. The intent is to provide background information on the more serious aspects of radiation exposure. This section also addresses the practical aspects of handling the contaminated and/or exposed patient in an emergency situation, including recommendations on the precautions that should be observed in treating such cases.

Radiological exposure and contamination are not necessarily encountered together in a given situation. An individual may suffer exposure without being contaminated, and likewise, may be contaminated without suffering serious exposure. Thus, the clinical aspects of each condition are explained separately. Under emergency conditions, when initially confronted with an individual believed to have suffered exposure, health care providers should assume the patient might also be contaminated.

Because of the isolated yet life-threatening nature of acute radiation overexposures, physicians need to have a particular awareness of the signs, symptoms, and treatment of radiation injuries. At the same time, they need to increase their awareness of the potential hazard that radioactive contamination poses to medical personnel as well as the patient.

Very little instruction has been provided to the medical community in the handling, treatment or evaluation of individuals who may have suffered a radiation injury, so some medical personnel have reservations about doing so. While some caution is always appropriate, the risk of secondary exposure to medical personnel dealing with a contaminated patient is relatively small. In that context, the patient presented as having been exposed to radiation should first be evaluated for contamination, then for the potential effects of exposure.

The physician encountering a patient who has a history of, or purports to have a history of, radiation exposure must quickly assess the clinical picture and direct appropriate laboratory studies immediately. If the signs and symptoms of sepsis are present, immediate intensive antibiotic therapy is usually indicated.

Since radiation exposure is a seldom-encountered medical condition, it is imperative that expert assistance is sought quickly from health physicists, dosimetrists, and radiation safety experts, and a determination made whether other individuals may have been unknowingly exposed. (A listing of agencies that can provide such assistance is found in the Resources section of this document.)

If other individuals, particularly medical service personnel, are to be protected from unnecessary exposure, then each exposure incident must be carefully analyzed. This is best done by agencies assigned that responsibility. Reporting of exposure to appropriate agencies is vital for both the care of the patient and for the welfare of the general public.

Throughout this document, the underlying rule for health service personnel should always be:

Deal with the patient's medical condition first!

PART ONE - Radiation and Radiation Accidents

In this portion of the guide we'll examine how radiation accidents can occur, the basic types of radiation, and why it is important to understand the essential differences between exposure and contamination when dealing with radiation accident victims.

Most radiation-related accidents likely to be encountered by emergency medical personnel generally will involve radioactive materials or radiation-emitting devices being used in an industrial or institutional setting or while being transported. However, there also may be incidents in which victims result from the accidental or deliberate misuse of radioactive materials.

Industrial accidents cover a range of situations, from activities within nuclear power plants, isotope production facilities, materials processing and handling facilities, and the widespread use of radiation-emitting measurement devices in manufacturing and construction. Institutional accidents generally involve research laboratories, hospitals and other medical facilities, or academic facilities. Generally, the victim or patient is an individual who was directly involved in handling the material or operating the radiation-emitting device.

Transportation accidents may occur during the shipment of radioactive materials and waste. However, due to stringent and rigidly enforced regulations governing the packaging and labeling of radioactive material shipments, few of these incidents pose any serious threat to health and safety. Here the victims or patients are usually vehicle operators, pedestrians, or occupants of other vehicles who are unlikely to come in contact with the radioactive material involved. (Commercial and private aircraft accidents also may involve radioactive materials, primarily radiopharmaceuticals, carried as cargo, or radioactive instrument components, but these seldom pose a serious exposure risk. Accidents involving military aircraft generally pose no increased risk since radioactive weapons elements are sealed and shielded, and protected against accidental detonation.

There have been several incidents worldwide in which radioactive materials were unknowingly released by individuals unaware that they were dealing with a hazardous substance. Improperly or illegally discarded radiation sources have been opened by scrap dealers and others, causing serious contamination and lethal exposure to a number of people.

Another potential source of contamination and/or exposure that must be considered involves the deliberate dispersal of radioactive material by terrorists. The Oklahoma City federal building and World Trade Center bombings, the subway poison gas attack in Japan, the use of chemical and biological agents during the Gulf War, and other incidents have heightened awareness regarding the potential for terrorists acts involving what are now characterized as "weapons of mass destruction (WMD)".

A WMD incident in which chemical, biological, or radiological materials are used in conjunction with explosives or released environmentally under certain circumstances has the potential to cause significant numbers of casualties as well as creating widespread public panic. Such situations require a very different approach to ensure appropriate steps are taken to protect medical service providers and facilities against unnecessary exposure. These concerns are addressed under <u>Special Considerations</u> in Parts Two and Three of this guide.

EXPOSURE AND CONTAMINATION

Radiation is a form of energy. Radioactive materials and radiation-producing devices emit energy that can be harmful to human tissue and organs at excessive levels. Exposure is a function of the amount of energy emitted by a radioactive material, the distance between the source and the exposed individual, and the amount of time over which the exposure occurs. Remaining in proximity to even low-level radioactive materials (or contamination) for prolonged periods increases the amount of potential exposure.

In layman's terms, an individual who is subjected to radioactive energy is said to have been "exposed." If the energy comes from a sealed source or a machine, there is no contamination and, except in rare instances, the exposed individual is not radioactive. Assuming the patient has been removed from proximity to the radiation source or machine, there is no exposure threat to those handling the individual. The radioactive energy may have caused cell damage in the victim, but the energy is not residual.

However, if the patient came in contact with unconfined radioactive material in the form of airborne particles, liquid, or powder, the individual may be "contaminated." In this instance, the radioactive material may be on clothing, skin, or hair, or may have been absorbed, inhaled or ingested. As long as the contamination remains, the energy emitted by the radioactive material continues to provide "exposure."

In addressing the situation of an injured individual who may be contaminated with radioactive material, EMS personnel should always bear in mind that radiation and radioactive materials should be respected, but not feared. Problems associated with radiation accident patients are very similar to other types of medical problems that are handled routinely by EMS and hospital emergency room personnel.

Radiological contamination is similar to chemical contamination with respect to the threat it poses to the patient and the medical service provider. But unlike most incidents involving hazardous materials where the hazard is generally apparent, the presence of radiation is seldom obvious and cannot be detected by the human senses, only with specialized instruments. Similarly, minor radiation exposure can be compared to many types of simple poisoning that have few obvious symptoms, while higher levels of exposure can be diagnosed and evaluated through laboratory analysis.

TYPES OF RADIATION

Radiation exposure may result from several different sources. X-ray exposure, similar to that obtained from a medical x-ray unit, but in larger quantity, can result from exposure to radionuclides as well as to x-ray generating equipment. The only difference between gamma rays and x-rays is their origins. X-rays originate in the electron shells of atoms, while gamma rays originate in the nucleus. Once generated, they are virtually indistinguishable and have similar biological effects.

Radiation exerts a deleterious effect by the generation of free radicals in cells as well as by direct interaction and deposition of energy in cellular organelles. Only a portion of the x-ray or gamma ray energy from a source is deposited in the patient. The majority of x-rays or gamma rays, unless they are of unusually low energy, pass through the subject and exit without significant

interaction. Because of their energy and penetrating ability, gamma or x-rays can cause damage both at the surface and within the body.

Beta radiation, a particulate form of radiation where the energy is carried by a charged particle (an electron) may also cause damage. Because of the mass of the electron, the range of penetration is relatively small. In general, if damage is caused, it is at the surface of the body or internally from inhalation or ingestion. Beta particle radiation damage is not commonly encountered unless there is contamination or a particle accelerator beam was the source of exposure. Since all of the particle energy is deposited over a small area, significant local injury may occur, both externally and internally.

Depending on the size of the particle itself, or more correctly, the size of the particulate matter upon which the beta particle has been adsorbed, damage may be caused to interior parts of the lungs via normal inhalation processes. In some cases, inhaled material may be released from the lungs into the upper respiratory tract where it can be either exhaled to the atmosphere or subsequently ingested.

Alpha radiation consists of the nucleus of the helium atom. The electrons have been stripped away, and the resulting nucleus is highly charged. While it has the potential to cause significant damage, its range is very short. Whenever damage results from alpha particles, it is usually to the skin or another surface. Ingestion of radioactive materials containing alpha particles can result in significant internal organ doses. Alpha particles as well as beta particles are used in therapeutic radiology applications because of the large doses they can deliver over short ranges. For this reason, it is imperative to determine whether ingestion of, or contamination by, radioactive material has occurred. The proper development of a treatment plan is dependent upon whether or not there is ingested material.

Neutron radiation is a form of radiation commonly found in nuclear reactors, but it can also be found when neutron beams are improperly used or shielded in research laboratories. These heavy particles, when interacting with tissue, may create radioactive atoms in the tissue much as they form radioactive atoms within a reactor. In essence, some of the reactions that occur in a nuclear reactor could occur within the body when it is exposed to neutron irradiation. Isotopes of sodium or phosphorus may be produced in the exposed area. These isotopes may then circulate to other areas of the body where they could irradiate the entire subject. This is the only case where exposure alone can produce contamination.

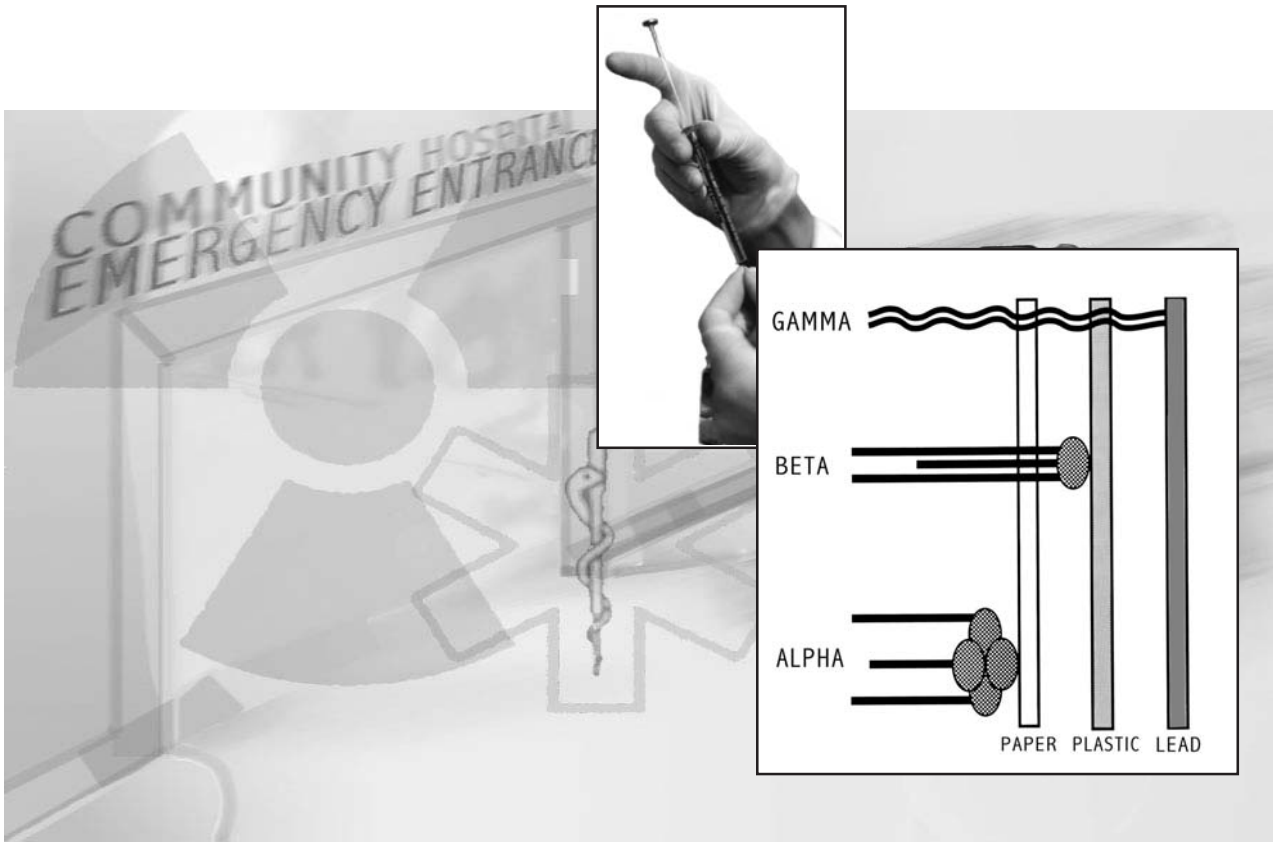
Exposure or contamination by neutrons is extremely rare. The primary method of exposure in this case would be an individual involved in a criticality accident. This is an accident where an unintentional chain reaction has occurred, releasing energy and neutrons. Due to the significant amounts of energy released in this type of accident, exposures are usually very high, and frequently fatal.

Exposure may occur anywhere radioactive materials are found. It is most likely to occur during the use of radioactive materials in a controlled or regulated industrial, scientific, or medical setting where misuse or an accident results in unintentional exposure. Exposure may also occur as a result of an accident during the transportation of radioactive materials. In rare instances, the theft or loss of radioactive materials may result in exposure to individuals who are unaware of the hazard or who subsequently discover the sources and tamper with them.

Industrial exposure to radioactive materials may occur either in the form of direct contact with the material or as a result of exposure to ionizing radiation. For example, industrial radiography sources are sealed. An industrial accident involving such a source would likely result in the individual being irradiated without having contact with the radioactive material itself. In a laboratory, radioactive materials might be in various chemical forms. If these materials were accidentally released in the laboratory, the result might be radioactive materials being deposited on the victim. These substances also might be inhaled or ingested by the workers.

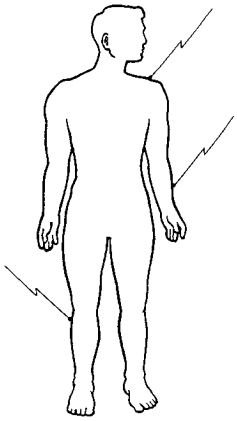
It is unlikely that an individual with external contamination would appear for treatment in a physician's office or emergency room without decontamination first having been attempted in the industrial facility involved. The strict government regulation of radioactive materials requires a trained Radiation Safety Officer (RSO) be designated wherever radioactive materials are used or stored. In the event of an accident, subjects should be examined for evidence of contamination and be decontaminated prior to release from the facility or assembly area, unless their other injuries are so severe as to require immediate medical attention.

The effects of the radiation exposure, whether associated with contamination or not, may not be immediate. The accident factors that determine a patient's symptomatology include the quantity, intensity, duration, and area of exposure.



The basic types of radiation accident victims are as follows:

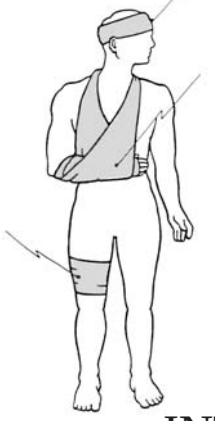
EXTERNAL RADIATION EXPOSURE



A person exposed to even a lethal dose of radiation generally presents no hazard to the individuals around him. The patient is not radioactive, and is no different from the patient who has been exposed to diagnostic x-rays.

[The only exception to this rule would be the person who has been exposed to significantly high amounts of neutron radiation. Persons or objects subjected to neutron radiation may become radioactive themselves. Such activation is extremely rare and noted here for information purposes only.]

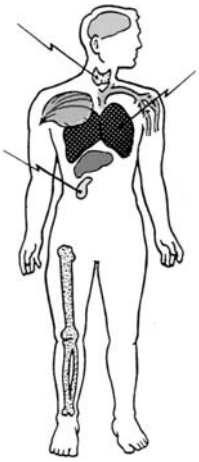
EXTERNAL CONTAMINATION



The individual who has external contamination presents a different situation. Problems associated with this type of patient are similar to those encountered with chemical contamination. The presence of external contamination usually means the individual has come in contact with loose or unconfined radioactive material, such as a liquid or powder or airborne particles from a radioactive source. The objective should be containment to avoid spreading the contamination. Anyone or anything coming in contact with a person or an object that is contaminated by radioactivity must be considered as being contaminated until proven otherwise. Isolation techniques should be implemented to confine the contamination and protect personnel.

INTERNAL CONTAMINATION

The patient who has been externally contaminated may also have received internal contamination by inhalation or ingestion. Internal contamination, however, is usually not a hazard to the individuals around the patient. The most common type of internal contamination involves the inhalation of airborne radioactive particles that are deposited in the lungs. Also possible is the absorption through the skin of radioactive liquids or the entry of radioactive material through an open wound. In all instances, there may be little or no residual surface or external contamination, but the patient may suffer the effects of exposure from the ingested or absorbed radioactive material.



Certain accident victims may be included in two or more of the categories. For example, an injured person may be contaminated both internally and externally with radioactive material. Such a patient should be handled with universal precautions, stabilized medically, appropriately decontaminated, and then evaluated for exposure by qualified medical experts.

External contamination may be eliminated or reduced by simply removing clothing and using conventional cleansing techniques on body surfaces, i.e., gentle washing and flushing that does not abrade the skin surface. Internal contamination, however, does not lend itself to conventional treatment using techniques normally associated with such problems as chemical poisoning and must be evaluated by experts.

PART TWO – At the Accident Scene

FIRST RESPONDER CONSIDERATIONS: ON-SCENE EMERGENCY TREATMENT AND TRANSPORT PROTOCOLS FOR CONTAMINATED OR EXPOSED PATIENTS

EMS personnel responding in a situation where radiation is involved or suspected need to keep in mind that the first priority remains the expedient delivery of appropriate emergency medical services to the patient, including transport to a hospital.

Deal with the patient's medical condition first!

In a first responder situation, ambulance, rescue, or medical services personnel will not know whether the patient is contaminated or exposed unless: (1) they are advised in advance by the party requesting assistance, (2) they are advised on arrival by other responders such as police or fire officials that radioactive materials are present at the scene, (3) they are advised by the patient that he or she is contaminated or was exposed, or (4) they determine from their own observation of the accident site that contamination or exposure is a possibility, i.e., from visual signs, placards, or documents such as shipping papers.

Information regarding the source of the radiation, type of radioactive material involved, and length of time of exposure is valuable data that should be gathered at the scene if possible (see Attachment 1-sample form), but it does not alter the role of EMS personnel with respect to the handling and transport of the patient.

At the same time, it is important that EMS personnel remember the distinction between exposure and contamination, and that they keep in mind the fact that there is little, if any, chance that they will ever encounter a radiological incident that poses a serious threat to their own health and safety. While accidents involving small amounts of radioactive material may occur in industry or commerce at any time, incidents that involve high-level, dangerous amounts of radiation are extremely rare and almost never occur outside the surveillance of qualified experts. Laws and regulations in Illinois governing the transport of high-level radioactive materials require packaging, escorts, and security to guard against anyone being accidentally exposed or contaminated.

❖ The patient that is known to have been exposed but who is not contaminated requires no special handling other than that appropriate to his illness or injury. *Such a patient presents no radiological threat to medical personnel. The patient is not radioactive.*

❖ When contamination is known to be present, or suspected but unconfirmed, EMS personnel should take steps to minimize the spread of contamination to themselves and the transport vehicle. Handling of contaminated injured involves the use of three basic principles: common sense, cleanliness, and good housekeeping.

Let's examine some typical situations and consider the appropriate procedures when a radiologically contaminated or exposed individual is or might be involved.

1. INDUSTRIAL ACCIDENTS

Radiation in the form of external contamination can be detected and measured with an appropriate type of radiation survey meter. EMS personnel responding to an accident at a facility where radioactive materials are in use will be met in most instances by a member of the facility staff responsible for radiation protection. That individual, usually known as the Radiation Safety Officer or RSO, should be capable of performing contamination surveys of the patient or at the very least advising medical personnel of the potential that the injured party is contaminated. Record any information provided that relates to the contamination or exposure of the injured party even if you do not fully understand the significance or terminology. The information may be crucial to emergency room staff or physicians trying to determine appropriate treatment. See Forms-Attachment 1 for an example of the type of information that should be obtained. In some instances, depending upon the facility's emergency protocols, the RSO or other radiation protection technician may accompany the patient or follow the ambulance to the receiving hospital to provide monitoring or contamination control assistance.

EMS personnel who observe signs or symbols indicating radiation hazards in the area where the injured person is located should ask if contamination or exposure is a possibility. If no one is available to answer the question with certainty, assume contamination or exposure, or both, have occurred. If the injured party is wearing a film badge, thermoluminescent dosimeter (TLD), or other dosimetry or detection device, keep the device with the patient while he or she is being transported to the hospital if at all possible. Advise hospital staff of the device to ensure it is removed before any X-rays are taken. If the device is confiscated at the facility, note that fact on the patient record and advise the receiving hospital. Expedient processing of the detection device may provide critical information about the type and length of exposure.

If a patient must be transported before conclusive information about contamination or exposure is obtained, the receiving hospital should be notified as quickly as possible of the potential for a contamination or exposure problem. Prompt notification will ensure that the receiving medical facility has time to prepare an isolation area and implement appropriate emergency protocols prior to the arrival of the patient. Request that the receiving hospital make arrangements to provide for monitoring of the ambulance and EMS personnel, as well as the patient, upon arrival.

Many larger hospitals today have Nuclear Medicine Departments that employ physicians and technical personnel who are trained in the use of radiation detection and measurement instruments. At other hospitals, the Radiology Department may have trained personnel on staff or on-call who can assist. Often a simple call to the hospital's Radiation Safety Officer (RSO) can provide all of the radiation-related assistance required for both the ER staff and the incoming EMS crew. If the facility does not have an RSO or ready access to detection equipment and radioactive contamination is suspected, qualified assistance can be obtained through the Illinois Emergency Management Agency- Division of Nuclear Safety (217) 782-7860.

2. TRANSPORTATION ACCIDENTS

Advised that contamination or exposure may have occurred, response personnel should ask if any effort has been made by a qualified individual to monitor the patient with radiation detection survey equipment. If such equipment is available, it may be utilized to confirm the presence of radioactive contamination and to give some indication of the levels of activity being encountered. This information can be very helpful to trained medical or radiation protection personnel in evaluating the need for treatment or precautions.

❖ (NOTE: The sensitivity of detection instruments varies considerably, and such factors as the proficiency of the individual conducting the survey can greatly affect the results obtained. Record any information available, but use it only as a guide to determine whether contamination control protocols need to be implemented during the transport of the patient. As a general rule, unless you have been thoroughly trained to interpret survey readings, do not make assumptions about "safe" levels of contamination or exposure. The fact that you are able to confirm (or discount) the presence of contamination at the scene of the accident should dictate the need for appropriate precautions. Moreover, providing that information to the hospital prior to arrival is crucial in helping the hospital determine how best to address the patient's medical condition.)

Upon arrival at an accident scene where radiation is suspected or known to be present, ask whether the patient has been monitored for contamination. If the response is affirmative and the patient is contaminated, ask which areas of the patient's body are contaminated and how that was determined. Ask the monitoring personnel to write down the levels of activity detected, the type of instrument used, and if they know, the type of radioactive source involved. Commonly available burn sheets can be effectively utilized to record this data. [This information should be provided to the receiving hospital during the transport of the patient and be made part of the patient's admission record.]

HANDLING THE CONTAMINATED PATIENT

If contamination is known or suspected, double-glove before touching the patient. Complete the necessary evaluation of the patient's medical condition and provide the immediate emergency medical services required, i. e., treatment of wounds, splinting, CPR, etc., avoiding any unnecessary contact with contaminated areas.

If you remove clothing from the patient that may be contaminated, it is strongly suggested that you leave it at the scene. Do not attempt to bring any extraneous item known to be or suspected of being contaminated with you in the ambulance. It will only increase the risk of spreading the contamination. Other emergency responders present, such as fire or law enforcement personnel, should be instructed to collect any clothing or other personal articles left behind using clean gloves, place the materials in a plastic bag along with the gloves, and seal the bag inside another clean bag. The bags should be labeled as containing potentially radioactive material and should

be turned over to the Illinois Emergency Management Agency- Division of Nuclear Safety or other appropriate health services agency as soon as possible for analysis. If there is no one present willing to handle such materials, ask that they be kept under surveillance at the scene while the IEMA or other appropriate agency is contacted to retrieve them.

Before moving an injured, contaminated (or potentially contaminated) patient, drape the stretcher, backboard, or other device being used with a blanket, sheet, or other material that can then be wrapped around the patient, a process known as "cocooning." Once the process is completed, remove the outer set of gloves, place them in a plastic bag or other secure container, and re-glove.

To the extent it is practical, cocooning the patient is useful in preventing the spread of removable contamination from the patient and his clothing to the EMS personnel, stretcher, and the interior of the ambulance during transport. Obviously, if cocooning interferes with the provision of necessary medical treatment or monitoring during transport, it should not be attempted. Non-porous wraps such as plastic or rubber sheeting are preferable materials for cocooning a patient, but may not always be practical or available. A blanket or cloth sheet may be used. If it becomes necessary to remove a portion of the wrap during transport to treat the patient, try to do so carefully and only to the extent necessary, turning the exterior side of the wrap inside itself so that any contamination clinging to the interior surface is not spread to the attendant or vehicle. Again, while minimizing the potential spread of contamination is desirable, it should never take priority over treatment of the patient's medical condition.

During transport, in addition to providing information about the patient's medical condition, confirm with the receiving hospital that the facility is aware the incoming patient is or may be radiologically contaminated, and that appropriate steps are being taken to isolate the patient upon arrival.

Upon arrival at the receiving hospital, EMS personnel should move the patient immediately to the designated isolation/treatment area, avoiding if at all possible any contact between the patient and hospital staff until the patient is in the isolation area. The objective is to ensure that anyone coming in contact with the contamination remains in the isolation area until it is determined whether the contamination has been confined.

EMS personnel must not leave the isolation area until they have been surveyed for contamination by qualified monitoring staff and, if necessary, decontaminated. Likewise, any equipment, including the vehicle in which the patient was transported, uniforms, stretchers, etc., that is found to be contaminated should be isolated until it can be properly decontaminated.

All materials used to handle and treat the patient or that may have come in contact with the patient during transport, including gloves, pads, bandages, splints, oxygen masks, blood pressure cuffs, stethoscopes, etc., and any wastes remaining in the ambulance should be considered

contaminated. Carefully collect all such materials, place them in plastic bags as you would hazardous waste, and label the bags **"RADIOACTIVE - DO NOT DISCARD".** Turn over the materials to hospital authorities for monitoring, decontamination, or disposal.

Once the contaminated or exposed patient has been turned over to hospital staff for evaluation and treatment, fully document your actions during the emergency response. In particular, note the amount of time that elapsed from your arrival at the accident scene to the arrival at the receiving hospital, and indicate by name which EMS personnel had contact with the patient. Such information may be helpful to medical and radiation experts in calculating any potential exposure from external contamination. Even though the amount of contamination is likely to pose no immediate hazard to EMS personnel, where possible, and as a precaution, experts will want to calculate exposure for each individual involved to ensure that they are below regulatory limits established by state and federal agencies.

If radiation surveys indicate the interior of the transport vehicle is contaminated, the vehicle should be removed from service, locked, and isolated until radiation experts make a determination on the most practical means for decontamination**. Do not attempt to decontaminate the vehicle without assistance and advice from experts.** (In any instance where removal of a single ambulance or rescue vehicle due to contamination would compromise the ability to respond to a life-threatening situation, consult with radiation authorities about the levels of contamination present and what steps can be taken to mitigate the hazard until thorough decontamination can be accomplished.)

SPECIAL CONSIDERATIONS

Large-scale incidents, such as those involving catastrophic damage and mass casualties from such occurrences as a tornado, earthquake, or explosion, requires a different approach than the small-scale incident in which only one or two victims are encountered. The concern here is with the type of contamination that may be present and its potential effect on the ability to sustain the viability of medical services. It is improbable that most natural disasters would release radioactive materials in sufficient quantities to cause mass casualties, but there are two man-made situations that could produce such results.

One is an accidental explosion that occurs within a facility where radioactive materials are used or stored. It is possible that some limited amount of radioactive material could be released as a direct result of the explosion or any ensuing fire. Local fire officials have access to information about where licensed radioactive materials are housed in their communities and can assist in determining when such a hazard might exist.

The other large-scale man-made incident that potentially poses a serious risk is an act of terrorism. In any terrorist incident that produces mass casualties and extensive damage, the first consideration should be whether some chemical, biological or radiological agent was involved. The presence of a hazardous material with the accompanying prospect of contamination and exposure drastically alters the approach that should be taken by medical service personnel.

❖ When such involvement is known or suspected, the injured should be triaged, monitored and decontaminated to the extent possible, <u>at the scene</u>. The movement of contaminated or exposed

patients to hospitals poses the substantial risk of contaminating transportation resources, treatment facilities, and staff, rendering these resources useless for the treatment of uncontaminated injured.

EMS protocols should clearly outline the steps to be taken when there is notification of a terrorist incident possibly involving a hazardous material. Among the considerations are the following:

❖ Dispatching on-shift and off-shift emergency staff to establish on-scene triage and treatment capabilities. (Most mass casualty plans provide personnel allocation schemes that can be adapted for this purpose.)

❖ EMS providers and rescue services should not bring victims directly to hospitals unless specifically directed to do so.

❖ As early as possible after notification, contact state support agencies for assistance with monitoring and decontamination functions and disposal of contaminated materials.

It is also important to remember that any terrorist incident is a criminal act, and that while the first responsibility of medical service providers is to the patient, necessary interaction with law enforcement officials will be an integral part of the process from the outset. No physical evidence should be discarded without authorization from law enforcement officials, and all activities should be recorded as carefully and thoroughly as possible.

PART THREE – At the Hospital

CLINICAL AND PRACTICAL INFORMATION
FOR PHYSICIANS AND NURSING STAFF
EVALUATING AND TREATING RADIATION ACCIDENT VICTIMS

BIOLOGICAL EFFECTS OF RADIATION

For the emergency room physician and trauma team presented with an accident victim that may be radiologically contaminated or exposed, it is important to understand how radiation can affect the human body and the diagnostic tools available to assist in evaluating the patient's condition.

Ionizing radiation is a form of energy related to light, radio waves, or microwaves. The interaction of this radiation with tissue causes two main effects. First, radiation may directly damage intracellular molecules. Second, free radicals may be formed in the cell, which can lead to other cellular damage. The survival of the cell depends upon the amount of damage it sustained as well as its ability to undergo auto-repair.

The auto-repair mechanism, and the effect it produces within the cell itself, is a function of the normal division time of the particular cell in question. Cells that divide more slowly can usually repair themselves before division has occurred. Cells that divide rapidly, such as the epithelial cells lining the gastrointestinal tract and cancerous cells, are much more susceptible to radiation damage, and once irradiated, are frequently unable to divide. This fact explains why radiation is used as a treatment for cancer, as well as why examination of the gastrointestinal tract provides an early indication of radiation overexposure.

The types of damage that cells undergo may be classed broadly as *somatic* or *genetic*. Damage to somatic cells may be evident in the exposed individual. Genetic effects do not appear in the exposed subject, but may occur in future generations as a result of the exposure. Exposure to certain chemicals or radiation may result in the development of cancer in the exposed individual. The same exposure also may result in genetic effects that will not be expressed until future generations.

Another important radiation exposure principle is that of *stochastic* or *deterministic effects.* A stochastic effect assumes that any dose, no matter how small, increases the human risk even if no effects are observed. Genetic effects and carcinogenesis are thought of as being stochastic. Deterministic effects are those for which the severity of the effect varies with the dose. For example, reddening of the skin, hair loss, cataracts, bone marrow effects, and impaired fertility are considered deterministic effects.

Cells vary in sensitivity to radiation by where they are in their life cycle. Cells in the division stage are most sensitive to radiation. Tissues with a high rate of cellular turnover (where cells are rapidly dividing) are most sensitive to radiation effects. For example, the bone marrow, the skin, the gastrointestinal (GI) tract, and particularly rapidly dividing cells in fetuses and young children are very sensitive to radiation injury. It is therefore logical that the radiation effects noted clinically are first observed in these organ systems. Tissues such as bone and muscle show few acute effects of radiation.

CLINICAL RADIATION EXPOSURE SYNDROMES

Exposure to radiation may be either local, i.e., extremity or other portion of the body, or generalized, frequently referred to as a whole-body exposure. Local exposure tends to result in injury only to the area that was exposed. Exposure of this type is rarely lethal although significant local injury may occur. Whole-body, or nearly whole-body exposure, by a significant dose of radiation can result in a systemic acute radiation syndrome. Both the local and systemic acute radiation syndromes demonstrate four distinct clinical phases. The onset and duration of each phase is a direct result of the intensity of the exposure.

Phase I - THE PRODROMAL PHASE

The first clinical phase after radiation exposure is the prodromal period, lasting only 24 to 48 hours. The severity of the symptoms is directly related to the intensity of the exposure. If the entire body is exposed to a small dose of ionizing radiation, the symptoms are vague, and in some instances non-detectable.

Discomfort and a clinical picture mimicking an acute viral illness may be present. Without a history of definite radiation exposure, diagnosis during this period of time may be difficult. However, a patient with a history of radiation exposure and the acute onset of generalized vague symptoms requires immediate evaluation, since supportive measures may have to be instituted later. Local radiation exposure may result in skin erythema similar to that seen in sunburn. Alternatively, paresthesias or other sensory changes may occur in the exposed region.

Phase II - THE LATENT PHASE

This is generally an asymptomatic period occurring after the prodromal phase and before the manifest illness. The length of this phase is quite variable, and is directly related to the total dose of radiation. At high exposure levels, this interval may last only several hours, whereas at lower exposure levels it may last up to three weeks.

Phase III - THE MANIFEST ILLNESS PHASE

It is during this phase that the most severe symptoms of radiation exposure will be identified. The organ systems involved as well as the severity of the illness are related to the dose of radiation received. This phase leads to either recovery or death.

Phase IV - RECOVERY OR DEATH

It is during this phase that the patient either recovers from injury, or succumbs to its effects. Recovery is on the order of months with slow wound healing and gradual return of normal hematological parameters. Long-term effects are not seen during this period, but may take years to manifest themselves.

ACUTE RADIATION SYNDROME

One of the first tasks in evaluating a patient for acute radiation syndrome is to categorize the level of injury. This categorization may be done by exposure, if the exposure level is known, or by clinical symptoms if the exposure level is uncertain.

To some degree categorization is subjective, and there is considerable overlap among the categories. The placement of patients in one or another category is useful primarily for predicting outcome. Categorization also assists the managing physician in marshaling appropriate resources to support the patient until recovery can occur.

CATEGORIES OF INJURY

Categorization is based upon the organ system involved and the approximate dose received by the patent. Outlined below are the clinical findings one may anticipate encountering for each of these groups.

Group I - (Exposure level 50 to 150 rads; .5 to 1.5 Gy) These patients are the least severely involved and affected as a group. At times, no evident clinical symptoms occur, or there may be a mild prodromal syndrome and minimal laboratory changes. Some subjects experience nausea and vomiting, which lasts up to 24 hours.

Group II - (Exposure level 150 to 400 rads; 1.5 to 4.0 Gy) Patients in this group demonstrate predominantly hematological symptoms. This may be identified as the hematopoietic syndrome. The prodromal symptoms in this group of patients again consists of nausea and vomiting, similar to Group I, but in addition may include diarrhea, fatigue, and weakness. These symptoms appear within a few hours of exposure and are generally resolved by 48 hours. Following the prodromal phase there is a latent period of several weeks during which the patient is asymptomatic. This is the period a physician might expect to see the patient with vague symptomatology in an office or in an emergency room setting. Immunosuppression develops during this period of time. The bone marrow is suppressed with progressively decreasing leukocyte counts and platelet counts (see discussion later concerning formed blood elements). Patients may present infection secondary to leukopenia or a bleeding diathesis secondary to thrombocytopenia. Recovery, if it occurs, requires an extended period of time.

The radiation dose to patients in this particular category is significantly greater than in Group I. The bone marrow suppressive syndrome is associated with doses on the order of 150 to 400 rads (1.5 Gy to 4.0 Gy). This dose of radiation equates to an $LD_{50/60}$. This notation is similar to that used with therapeutic drugs, i.e., 50 percent of these patients will die by 60 days post exposure. An $LD_{50/60}$ dose for radiation is estimated to be 250 to 350 rads (2.5 Gy to 3.5 Gy). The $LD_{50/60}$ assumes that there is no therapeutic or supportive therapy undertaken in this population. In this patient group, appropriate clinical management and supportive measures may significantly improve the chances of survival and recovery.

Group III -(Exposure 400 to 600 rads; 4.0 to 6.0 Gy) Patients present symptoms similar to those in Group II but at a greater level of severity. The dominant feature is commonly a hematological response leading to a bleeding diathesis or sepsis. Survival in this group of patients is doubtful without supportive therapy. Such therapy might include reverse isolation and blood products

support, as well as antibiotic coverage. Those measures that would be undertaken for patients suffering marrow depression secondary to chemotherapeutic agents might also be appropriate in this patient group.

Most Group III patients will recover marrow function if they survive the manifest illness phase. Bone marrow transplantation remains a controversial issue in radiation exposure, but should be seriously considered if a suitable matched donor and appropriate facilities for transplantation exist. Non-cross-matched, indiscriminate bone marrow transplantation is seldom justified. Indiscriminate transplantation may, in fact, jeopardize the life of the patient.

Group IV -(Exposure 600 to 1500 rads; 6.0 Gy to 15.0 Gy) Both the prodromal and latent phases in this population are shortened. The manifest illness usually occurs several days after exposure. The dominant feature of this form of exposure is a gastrointestinal syndrome. The GI epithelium suffers greatly at this level of exposure.

The denuding of GI epithelium places the patient at risk for internal hemorrhage and sepsis. Secondary to the loss of intestinal mucosa, severe diarrhea with fluid loss is also a feature of this syndrome. Sterilization of the intestinal flora with antibiotics may help reduce or prevent systemic sepsis. In large part, the survival of the patient through this stage of illness depends upon the ability of the intestinal mucosa to regenerate. However, intensive supportive measures are required while awaiting the regeneration of the intestinal epithelium. The transfusion of blood products, antibiotics, and fluid support is absolutely essential.

If the patient survives the acute gastrointestinal syndrome, he becomes subject to the bone marrow hematologic syndrome. Once again, the patient will have to be supported throughout this as were Group III patients.

The $LD_{50/60}$ in patients in this category has been estimated to be 1100 rads (11.0 Gy) when intensive supportive therapy is used. This supportive therapy includes bone marrow transplantation.

Group V - (Exposure greater than 1500 rads; 15.0 Gy) These patients progress to death quickly, usually within 48 hours. They suffer from the acute neurologic syndrome, although two deaths at this exposure level have been ascribed to acute cardiovascular collapse. While the patients go through a prodromal phase, this phase is very short and the manifest illness phase is nearly immediate. The presenting central nervous system symptoms are confusion, ataxia, and sensory impairment. There is no known therapeutic intervention for this population and, in general, supportive measures are employed although the outcome is not altered.

In taking the history and performing a physical examination on the patient, it is important to determine which symptoms are present and what the time interval has been since the alleged exposure. Some idea of the exposure level may be obtained if the examiner can obtain an accurate history with regard to the interval since exposure. For example, patients with the hematologic syndrome several weeks after exposure could be grouped as Group III patients on clinical grounds. Since they did not manifest the GI syndrome, they did not receive more than 600 rads in all likelihood. Both the prognosis and therapeutic interventions depend on determining at which dose level the patient was exposed.

LOCAL RADIATION INJURY

Local radiation injury may appear as an independent entity or concurrently as part of the acute radiation syndrome depending upon the manner of exposure. Most commonly, the combination of the acute radiation syndrome and local radiation injury results from handling a sealed source. The hand itself undergoes intense exposure since it was in direct contact with the source.

The clinical findings in the manifest illness stage are similar to those seen from thermal burns and can be classified into three types of acute injury. The "rules of nine" evaluation used in the management of burn victims is also useful in describing the extent of surface injury involved in radiation burns. However, a significant difference from standard thermal burns is that the volume of tissue affected by a radiation burn is significantly larger than the surface area affected. Radiation injury almost always involves a large volume of underlying tissues as well as the skin.

Burns resulting from industrial exposure may not always represent radiation injury. Studies of radiation accidents have indicated that symptoms associated with thermal burns caused by live steam or a chemical explosion are also common in patients with radiation exposure. After checking for contamination, the management of pure thermal burns should be in the conventional fashion. Below is a classification system for radiation burns.

Type I - ***(Local exposure 600 to 800 rads; 6.0 to 8.0 Gy)*** This injury is similar to a first-degree burn. A local exposure at this level will result in a local prodromal symptom consisting of warmth, itching, or mild erythema. This response is transient and is followed by a latent phase of several weeks. In the manifest illness phase of the local injury, the skin becomes reddened, and dry desquamation may occur. The area will usually progress to healing without impairment of function or long-term deleterious effects.

Type II - ***(Local exposure 800 to 2000 rads; 8.0 to 20.0 Gy)*** Again, the prodromal phase consists of sensory changes including itching, pain, and erythema. A latent phase of one to two weeks occurs, and the clinical picture of manifest illness resembles a second-degree thermal burn with blistering. The burns resulting from a Type II radiation burn injury are painful, slow to heal, and very prone to infection.

Type III - ***(Local exposure in excess of 2000 rads; 20.0 Gy)*** After exposure at this level, erythema appears quickly and intense pain accompanies it. The prodromal phase is very short to nonexistent, followed rapidly by blistering and desquamation. Like a thermal third-degree burn, this is a full-thickness injury, which may require grafting for final healing. If an extremity is involved, amputation may become necessary.

Type IV - ***(Chronic exposure)*** Burns in this category result from chronic exposure at low doses. This results in a chronic radiation dermatitis, which may ulcerate. The ulcers heal

HAIR LOSS

Epilation of exposed areas can occur and is a useful indicator in estimating local dosage. Levels of 300 to 400 rads (3.0 Gy to 4.0 Gy) cause hair to fall out between the third and fourth week after exposure. If the dose is greater than 500 to 600 rads (5.0 Gy to 6.0 Gy), the epilation may be permanent.

THERAPY OF RADIATION BURNS

Skin grafts may have difficulty taking, and the burn may appear to be progressing poorly. It is recommended that patients be referred to a burn center for therapy and follow-up if the patient's general condition permits it.

HISTORY AND PHYSICAL EXAMINATION OF THE EXPOSED PATIENT

In all clinical settings, it is important to err on the side of caution. Radiation exposure should not be dismissed as a possible etiological factor in the patient's symptom complex until it can be eliminated with certainty. The failure to suspect a serious radiation exposure may result in an unrecoverable loss of information and may lead to inappropriate treatment planning and execution.

Radiation injury may not manifest itself for days to weeks after the initial exposure unless high doses are involved. A patient with the possibility of radiation exposure must be considered to have been exposed until proven otherwise. The information obtained from a detailed patient history can assist in determining whether exposure to ionizing radiation may have occurred. Possible causes of accidental exposure include industrial radiography sources, medical implant sources, or particle accelerators. In addition, potential exposure in a chemistry lab or power reactor should be explored while obtaining the history.

Regulations governing the use of radioactive materials require numerous safeguards, such as signs identifying their location, locked barriers to prevent entry into these areas, proper labeling of packages containing these materials, and other precautions. Nuclear power plants are also strictly regulated and constructed in a manner that minimizes the chance of an accident, as well as the release of radioactivity to the environment should an accident occur. Federal, state and local governments have detailed plans to respond to such an incident, and to further minimize potential exposure through population relocation when necessary.

The individual should be asked why he believes he was exposed to ionizing radiation. This question is extremely important in all cases, but especially critical if a nuclear incident has occurred at some remote location. Due to publicity about the incident, a patient may believe he was exposed simply because he was in the vicinity. A physician will probably face numerous patients under these circumstances, and it is essential for the patient's emotional and psychological well being that a physician be able to determine whether or not radiation-related injuries have occurred.

Patients often confuse radiation accidents with other accidents. For example, exposure to microwave radiation, infrared, or ultraviolet radiation all cause damage that may appear to be similar to an ionizing radiation injury. However, in all of these cases, the clinical course differs significantly from that indicated for radiation exposure. Once again, determination of the time course of the symptoms from the alleged exposure is critical. Obtain data on the place and date of

exposure. Subsequent to completing the history and physical examination, notify radiation protection agencies as well as the institution or business concern where the suspected exposure occurred. The assistance of the employer will be vital in determining the nature of the exposure and preventing future exposures to other workers.

With regard to the individual patient, determine if possible the dose received, and whether the exposure was whole body or localized. The clinician may be able to predict and prepare for changes that will occur over time if this information can be ascertained. An appropriate treatment plan then can be developed and resources marshaled to deal with the expected symptomatology.

If possible, the strength and type of the radiation source should be ascertained. The distance the patient was from the source, the duration of the exposure, and the presence or absence of shielding should also be investigated. These data will be important for health physicists to reconstruct the accident and calculate approximate exposure.

Radiation workers are monitored by film badges or thermoluminescent dosimeters (TLDs) to determine their cumulative exposure. In some cases the workers also wear a device called a self-reading dosimeter. All of these devices can assist greatly in estimating the dose received. Ask if the patient wore a badge or dosimeter, and the location of that device at the present time.

The review of symptoms is essential. The prodromal symptoms often mimic a viral illness. Does the patient have the flu or does he have the prodromal radiation syndrome? Do other family members have the flu? Has the patient been exposed to individuals with infections? Before reaching the conclusion that the patient is in the prodromal phase, appropriate history and laboratory examination should be undertaken.

If the patient has infection symptoms, the prognosis may be grave. Depending upon the interval since exposure, the subject may be experiencing portions of either the gastrointestinal or hematologic syndromes. Since the patient may be suffering from immunosuppression, immediate laboratory testing and intervention may be required to stabilize the victim.

Physical examination may be unrevealing, except in the more severe cases. If the exposure was local, erythema or desquamation may be seen. Charring of the skin usually involves a thermal component as well as radiation. Radiation alone does not produce charring of the skin. The correlation of the physical and history findings with the time course is important. Clinical symptoms the physician should carefully examine include sepsis, diarrhea, nausea or vomiting, and confusion or ataxia. Most commonly, however, the patients have no physical findings at all.

USE OF LABORATORY TEST INFORMATION

Carefully performed laboratory tests early in the diagnostic process will assist in the determination of total body exposure and help determine the initial medical management steps required. Trending of laboratory values is imperative if one is to estimate the severity of the exposure. Since the major test employed is the complete blood count (CBC) with differential count, small quantities of blood are all that is required.

ABSOLUTE LYMPHOCYTE COUNT — The absolute lymphocyte count is the first value to show any change after a significant radiation exposure. These changes occur rapidly and stabilize, reaching their nadir at three to five days post exposure. An exposure of 100 rads (1.0 Gy) will decrease lymphocyte counts to approximately 75 percent of their normal value. 200 rads

(2.0 Gy) will cause a decrease in lymphocyte counts to approximately 50 percent of normal value, and 500 rads (5.0 Gy) will result in lymphocyte counts being approximately 10 percent of normal. Radiation exposures of >500 to 600 rads (5.0 Gy to 6.0 Gy) will result in lymphocytes being absent or minimally detected. This is exceedingly important dosimetric information, since the absolute count of lymphocytes can be used to estimate exposure. Lymphocyte levels remain depressed for four to six weeks before starting to return to normal. Six months later, normal values should be detected.

Care must be taken in using the lymphocyte value to determine whether or not a patient has had radiation exposure if he has the prodromal symptoms. Influenza can result in diminished lymphocyte counts as well. Usually viral illnesses with lymphopenia will be present with atypical lymphocytes in contrast to radiation exposure. Severe depression of lymphocyte counts, however, is not a normal feature of viral illness and may be an indication of significant radiation exposure.

NEUTROPHIL COUNT — The neutrophil count is the best predictor of subsequent clinical infection. Exposures in the range of 100 rads (1.0 Gy) result in only a mild decrease of the neutrophil count. Exposures up to 200 rads (2.0 Gy) will result in a 50 percent decrease in the neutrophil count. In contrast to the lymphocyte count, the decrease in neutrophils is gradual, reaching its nadir at four to six weeks post exposure. At greater exposures the neutrophil count may actually rise in the first several days followed by a fall. This fall may be quite precipitous, dropping to 50 percent or less of normal counts within one-week post exposure. In a patient with more significant radiation exposure, there may be a plateauing of the neutrophil counts or even a transient rise at one to two weeks. This is almost invariably followed by a further decrease in the neutrophil count. If the patient survives, recovery of neutrophils is noted between the sixth and eighth weeks post exposure. As in chemotherapeutic regimens, patients should receive appropriate antibiotic coverage and isolation when the neutrophil counts become dangerously low. Susceptibility to opportunistic organisms may occur in this population as well.

PLATELET COUNT — As with the other formed blood elements, the effect on platelet count is related to the exposure level. Larger exposures will result in a decrease in the platelet count beginning within the first week or two post exposure. Lower levels of exposure will manifest changes at four weeks.

Transfusion with platelets becomes clinically indicated with a platelet count between 20,000 and 30,000. A bleeding diathesis is a serious concern, and the patient should be closely monitored. Platelet counts in the 20,000 to 30,000 range will commonly result from exposure of 200 to 500 rads whole body (2.0 G - 5.0 Gy).

RED CELL COUNT — Because of the life span of the red cell, it is uncommon to see anemia as a result of acute radiation exposure. Red cell depression may begin at six to eight weeks after exposure. However, at that time the marrow should be entering a recovery phase.

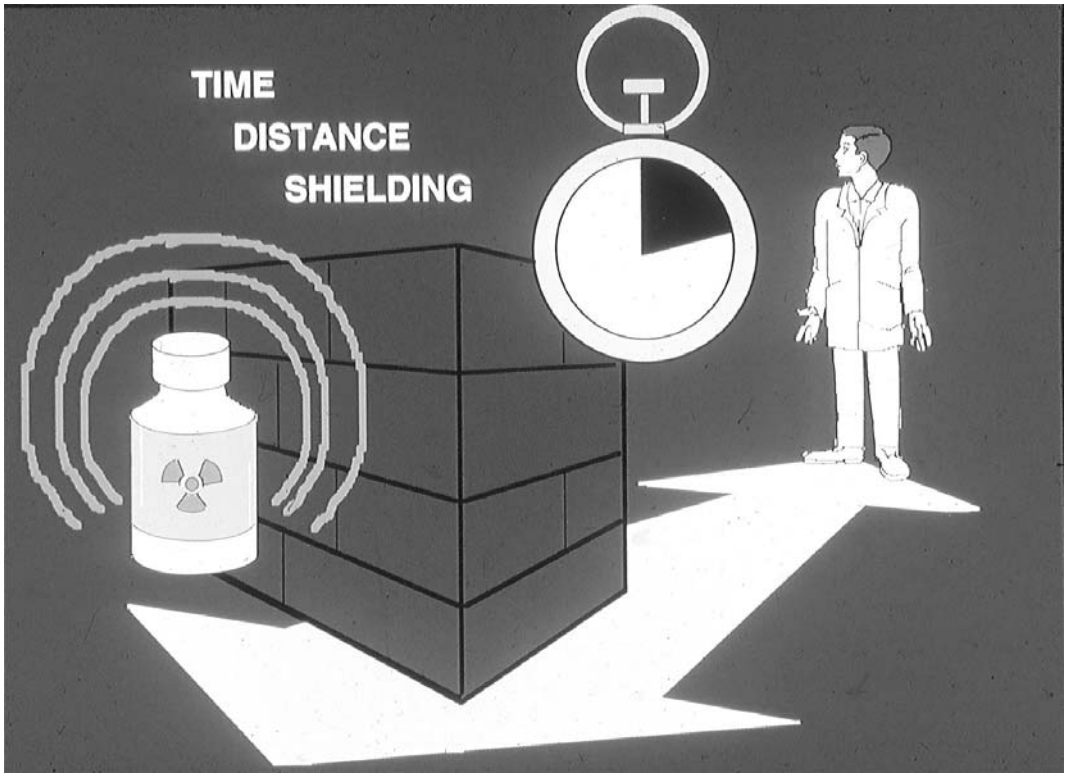
SPERM COUNT — Spermatogenesis is very sensitive to the effects of radiation, and changes may be seen with doses as low as 15 rads. Since the lifetime of the sperm cell is several weeks, a sperm sample should be obtained as soon as possible after exposure with additional samples taken at one month and then at two months to determine if there has been any effect. Fifteen rads exposure will produce mild oligospermia. A dose of 200 to 300 rads will produce azoospermia for one to two years. Doses above 500 rads (>5.0 Gy) may result in permanent sterility.

CHROMOSOMAL STUDIES — Chromosomal aberrations are a sensitive indicator of dose. Many different anomalies occur and may be detected at exposure levels below 5 rads. Thus, exposure to levels of radiation in the diagnostic radiology range may also produce chromosomal aberrations. Chromosomal studies are generally performed on peripheral lymphocytes, which are placed into culture media. Mitosis is halted at metaphase, and the chromosomes are examined.

The effects of radiation on chromosome mutation are not unique. Some viruses and medications can produce changes that are indistinguishable from radiation-induced damage. If there is a delay in obtaining the sample and analyzing it, there may be too few peripheral lymphocytes to culture.

Although an interesting technique, there are disadvantages to chromosomal studies on lymphocytes. First, the lymphocyte is the blood element that is most sensitive to radiation exposure and its numbers decrease significantly early in cases of high level exposure. It is important such testing be done early if it is to be performed at all.

Secondly, cytogenetic analysis is very time-consuming and the results may not be available for several days. Therefore, generally it is not used in management of higher-level radiation exposures. This technique is probably most useful in that group of patients who are exposed to small amounts of radiation. These patients do not have a significant drop in their lymphocyte count and may not experience any symptoms or demonstrate signs of exposure. Both local and whole body exposures can cause chromosomal changes. Correlation with the clinical history is required to determine if the number of chromosomal aberrations is due to a localized area of high exposure or relatively low whole body exposure.



CONTAMINATION -
CARE OF RADIATION ACCIDENT PATIENTS

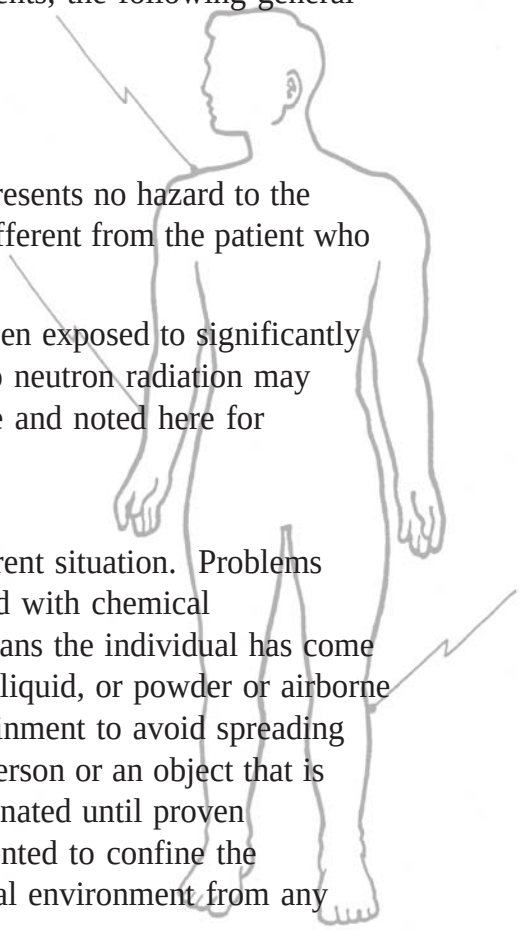
While an acute overexposure case is rare, the area of "contaminated injured" is a more probable occurrence from the standpoint of the physician.

In addressing the situation of an injured individual who may be contaminated with radioactive material, the physician should always bear in mind that radiation and radioactive materials should be respected, but not feared. Handling of contaminated injured involves the use of three basic principles: common sense, cleanliness, and good housekeeping.

Radiation can be detected and measured with a radiation survey meter, commonly known as a Geiger counter. Many hospitals today have Nuclear Medicine Departments that involve both physicians and technical personnel who are aware of the location and use of these instruments. Sometimes a simple call to the hospital's Radiation Safety Officer (RSO) can provide all of the radiation-related assistance required. If the facility does not have an RSO or ready access to detection equipment and radioactive contamination is suspected, qualified assistance can be obtained through the Illinois Emergency Management Agency- Division of Nuclear Safety (217) 782-7860.

Problems associated with radiation accident patients are very similar to other problems that are handled frequently by emergency room personnel. In order to enable a physician to be better prepared to handle and accommodate radiation accident patients, the following general information and guidelines are presented.

The basic types of radiation accident patients are as follows:



1. EXTERNAL RADIATION EXPOSURE

A person exposed to even a lethal dose of radiation generally presents no hazard to the individuals around him. The patient is not radioactive, and is no different from the patient who has been exposed to diagnostic x-rays.

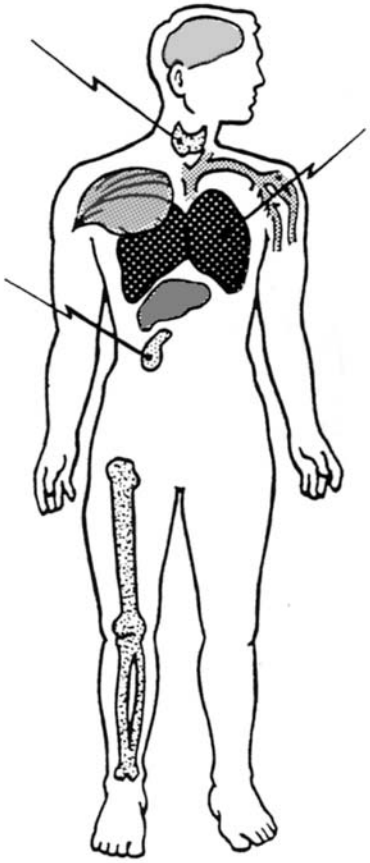
The only exception to this rule would be the person who has been exposed to significantly high amounts of neutron radiation. Persons or objects subjected to neutron radiation may become radioactive themselves. Such situations are extremely rare and noted here for information purposes only.

2. EXTERNAL CONTAMINATION

The individual who has external contamination presents a different situation. Problems associated with this type of patient are similar to those encountered with chemical contamination. The presence of external contamination usually means the individual has come in contact with loose or unconfined radioactive material, such as a liquid, or powder or airborne particles from a radioactive source. The objective should be containment to avoid spreading the contamination. Anyone or anything coming in contact with a person or an object that is contaminated by radioactivity must be considered as being contaminated until proven otherwise. An isolation technique should be immediately implemented to confine the contamination and protect personnel, other patients, and the hospital environment from any potential hazards.

3. EXTERNAL CONTAMINATION WITH WOUNDS

When external contamination is complicated by a wound or other illness, care must be taken to avoid cross-contamination. Any wound and surrounding surfaces should be cleansed separately and sealed off when clean. When crushed tissue is involved, early preliminary wet debridement following wound irrigation may be indicated. Further debridement and more definite therapy can await sophisticated measurement and consultant guidance. Treating contaminated patients without obvious injuries requires caution to avoid spreading the contamination until the patient is stabilized and can be decontaminated.



4. INTERNAL CONTAMINATION

The patient who has been externally contaminated may also have received internal contamination by inhalation or ingestion. Internal contamination, however, is usually not a hazard to the individuals around the patient. All of the patient's body wastes should be collected and saved for future analysis to determine the amount of radioactive material that may have been inhaled or ingested. Such knowledge is essential in determining the appropriate mode of treatment.

Certain accident victims may be included in two or more of the aforementioned categories. For example, an injured person may be contaminated both internally and externally with radioactive material. Such a patient should be handled with universal precautions, stabilized medically, appropriately decontaminated, and then evaluated for exposure.

External contamination may be eliminated or reduced by simply removing clothing and using conventional cleansing techniques on body surfaces. Internal contamination, however, does not lend itself to conventional treatment using techniques normally associated with such problems as chemical poisoning.

Refer to the section on Use of Laboratory Test Information (Pages 23 - 25) for guidance on what types of laboratory analysis might help identify the extent of internal contamination. In addition, whole body counts, urinalysis, and other techniques are available to evaluate internal contamination. However, it is strongly advised that you consult an expert about the appropriate diagnostic approaches before attempting to treat internal contamination (See Resources, Page 34).

EMERGENCY ROOM PROTOCOLS

The emergency room medical team can be of tremendous aid in preventing fear and hysteria. A calm, assured, and friendly attitude in conversations with the patient are important for the patient's psychological well being.

Emergency Room supervisors and staff should consider the following guidelines when notified of the imminent arrival of a radiation accident victim.

❖ In most cases, the hospital will be alerted prior to the arrival of a radiation accident patient, either by the ambulance transporting the patient, or by the police or other emergency response personnel at the scene. The patient may also be referred to the facility by an attending physician who should advise the hospital of the potential radiological considerations.

Upon notification that a radiation accident patient is enroute to the facility, the physician and the hospital's emergency room personnel should immediately perform the following actions:

1. Notify other staff physicians, nurses, and all appropriate allied health personnel such as trained personnel from the Nuclear Medicine Department or x-ray technicians from the Radiology Department.

2. Notify the Hospital Administrator. The Administrator may also desire professional consultation for the technical management of the case. The IEMA- Division of Nuclear Safety should also be contacted.

3. Obtain the emergency kit for radiation accidents, if available. The hospital should develop such an emergency kit containing the supplies recommended below.

4. The patient should be considered contaminated until it has been determined that he or she definitely is not. Emergency room personnel should take full universal precautions before approaching or handling the patient.

5. A separate space such as an isolation room or a cubicle should be prepared. Use disposable drapes or Chux to cover treatment areas that might become contaminated. If contamination is expected to be extensive, and the patient's condition is not serious, the morgue may be used as an emergency triage area since the autopsy table lends itself to efficient decontamination. In this case, use the morgue entrance to admit the patient, and assure the patient and his family that the reasoning behind this decision is contamination control.

6. The treatment area must be restricted from unauthorized personnel. Rope or portable screens may be used to restrict access to the area, and if available, facility security personnel should be posted to control access.

7. If possible, prior to the patient's arrival, survey the treatment area with a Geiger counter or other survey instrument to determine the "background" radiation level present, and display the reading prominently in the treatment area. It should also be noted on the patient's chart.

UPON THE ARRIVAL OF THE AMBULANCE, THE RESPONSIBLE PHYSICIAN SHOULD:

1. Give appropriate lifesaving assistance. Assess and treat the medical condition first. Acute injuries should always take precedence over a contamination problem. If the patient is conscious and the injuries are not life threatening, try to ascertain the circumstances under which the exposure or contamination occurred, including the size of the source, the radionuclide or radiation machine involved, and the length of time the patient may have been exposed. Such information may help determine the appropriate care for the patient as well as the extent to which staff precautions and decontamination may be necessary.

2. Check the patient for contamination. Survey the patient with the Geiger counter, noting any area where the instrument indicates radiation at or above a level that is twice the "background" level previously determined, and the difference. For example, if the background reading was determined to be 300 counts per minute (cpm), any reading during the patient survey that indicated levels of 600 cpm or greater should be considered an indication of the presence of contamination. Note any areas where such elevated levels exist, and complete the survey of the patient before initiating any decontamination efforts.

The individual conducting the patient survey should also determine that the emergency squad personnel and their equipment are free of contamination before allowing them to leave the premises.

(It is also prudent to ask if any members of the patient's family, friends, or co-workers may have also been exposed or contaminated as a result of contact with the patient. If so, they should be contacted, monitored, and, if necessary, decontaminated and evaluated.)

Any equipment, including the vehicle in which the patient was transported, that is found to be contaminated at or above the twice-background level should be isolated until it can be properly decontaminated.

3. As soon as the medical condition of the patient permits, decontamination should be attempted. The objective is to remove surface contamination while avoiding any action that would force the contamination into or below the skin level. Use tepid water so as to minimize opening and closing skin pores; use soap and lather abundantly; and flush the area thoroughly with water. Scrub the skin surface gently, and do not abrade the skin, if possible.

The area of highest contamination should be cleansed first. If an extremity alone is involved, the patient's clothing itself may serve as an effective barrier, and decontamination may be confined to the affected limb. Place all contaminated clothing in plastic bags or other suitable containers. Label these bags or containers "RADIOACTIVE - DO NOT DISCARD".

Wash water, unless markedly radioactive, may be flushed into the community sewer. The dilution factors of this method of disposal will reduce any hazardous effect. If the entire body is involved, or the clothing is permeated with contaminated material, showering or scrubbing will be necessary. Particular attention should be paid to the hair and scalp, body orifices, and body folds.

4. If a wound is involved, cover the wound with self-adhering disposable surgical drapes. Decontaminate the surrounding area skin surfaces, then seal off the cleansed area with disposable drapes. Remove the wound covering and irrigate the wound with sterile solution. Remonitoring the area to determine if contamination levels are being successfully reduced should follow each step in the decontamination procedure.

5. If confronted with a grossly contaminated wound with crushed tissue, the physician should perform simple debridement.

6. Resurvey the contaminated area(s) to determine if contamination levels have been effectively reduced. If not, repeat decontamination procedure a second time as aggressively as the patient's medical condition permits.

NOTE: As a general rule, it should be considered that any level of contamination equal to or greater than twice background merits a decontamination attempt. Likewise, after reasonable decontamination efforts have been made, contamination levels equal to or less than twice background should be considered successful. It is not necessary to remove 100 per cent of the contamination or seek to reduce contamination to background levels in order to protect the patient and staff.

Contamination that cannot be removed or reduced through washing or debridement is fixed and will not spread. It does, however, continue to pose a hazard to the patient, and experts should be consulted as to proper remedial treatment. Staff should continue to observe universal precautions in handling the patient pending a further evaluation of the situation.

7. All personnel must be monitored and, if necessary, decontaminated before leaving the restricted area.

8. Retain all protective clothing, instruments, and supplies used in treating the contaminated patient in containers marked "RADIOACTIVE - DO NOT DISCARD".

9. Once the patient has been decontaminated or staff is satisfied the remaining contamination is fixed, the patient may be moved from the treatment area. Isolate the treatment area and restrict entry until a thorough survey can be conducted by a qualified individual to determine that no residual contamination is present.

In the event a contaminated patient dies before decontamination is attempted or successfully completed, contact the Department of Nuclear Safety. Do not release the body or remove it from the facility until it has been confirmed that there is no potential for the spread of contamination.

SPECIAL CONSIDERATIONS

The steps outlined above will require modification in two instances; one in which the patient presents unannounced at the hospital declaring that radiation contamination or exposure has occurred, and the other in which radiation is an element in a mass casualty situation.

In the first instance, for the patient claiming to have been contaminated or exposed, the first step is to immediately isolate the individual and limit staff contact until a determination is made regarding the validity of the claim - through the gathering and verification of information regarding how the contamination and/or exposure occurred as well as actual monitoring of the individual if possible.

In the second instance, where radioactive material may have been disbursed accidentally as in the case of an explosion or fire or deliberately as in the case of a terrorist incident, the priority for hospital should be to avoid direct receipt of patients who may be seriously contaminated.

When the involvement of radiological material is known or suspected, the injured should be triaged, monitored and decontaminated to the extent possible, at the scene. The movement of contaminated or exposed patients to hospitals poses the substantial risk of contaminating transportation resources, treatment facilities, and staff, rendering these resources useless for the treatment of uncontaminated injured.

Hospital protocols should clearly outline the steps to be taken when there is notification of a terrorist incident possibly involving a hazardous material. Among the considerations are the following:

❖ Dispatching on-shift and off-shift emergency staff to establish on-scene triage and treatment capabilities. (Most mass casualty plans provide personnel allocation schemes that can be adapted for this purpose.)

❖ Directing EMS providers and rescue services not to bring victims directly to hospitals.

❖ As early as possible after notification, contact state support agencies for assistance with monitoring and decontamination functions and disposal of contaminated materials.

❖ Recognizing that some injured victims will go directly to hospitals from the scene on their own or with assistance from bystanders, an isolation area should be established within the hospital emergency room where such patients can be triaged, monitored and decontaminated before being admitted for treatment.

❖ Of particular concern where radioactive material is involved is the recording and retention of all information related to monitoring, contamination and exposure. Where available and used, dosimetry records should be kept and provided to the proper authorities. Recorders should be assigned to keep track of all medical service personnel who are involved in the treatment or handling of any contaminated or exposed patients.

It is also important to remember that any terrorist incident is a criminal act, and that while the first responsibility of medical service providers is to the patient, necessary interaction with law enforcement officials will be an integral part of the process from the outset. No physical evidence should be discarded without authorization from law enforcement officials, and all activities should be recorded as carefully and thoroughly as possible.

EMERGENCY PLANS AND KITS

When a radiation accident occurs, the hospital should be prepared to implement an emergency plan and appropriate treatment protocols immediately. The plan for the handling of radiological accidents should be an integral part of emergency room procedures, and the standing orders should be required reading for all affected personnel. Plans may vary from one facility to another, but should indicate which hospital personnel are responsible for the care of the exposed or contaminated patient; define those responsibilities; list the appropriate notifications required; indicate what resources are available; describe patient triage and treatment protocols; and specify the level of training required to handle a radiation incident.

THE "RADIATION ACCIDENT EMERGENCY KIT" AT A MINIMUM, SHOULD CONTAIN THE FOLLOWING:

1. A Geiger-counter type survey meter (if one cannot be obtained on an expedited basis from the hospital's Nuclear Medicine or Radiology departments). Follow the manufacturer's recommendations for maintenance and operation. If not available within the facility, instruments and trained assistance often can be obtained by contacting local fire departments, other hospitals, the IEMA- Division of Nuclear Safety, or one of the other organizations listed in the Resources section of this document, (Page 32).

(The reliability of such instruments depends upon their systematic maintenance and calibration. It is preferable to obtain a survey instrument that is in routine use rather than one that is stored for use as needed.)

2. A supply of heavy plastic bags for contaminated clothing, supplies, and equipment. Provisions should be made to label the bags as described below.

3. Containers for body wastes, labeled as "potentially radioactive."

4. Isolation equipment, i.e., gowns, gloves masks, foot covers, head covers, etc.

5. Forms to document all significant parameters and conditions measured or observed, as well as other emergency actions taken. The types of essential information required are shown on the sample forms included as an attachment to this document.

Additional information and guidance on emergency room preparedness for radiological emergencies can be obtained from IEMA. The agency can also provide assistance in training emergency room personnel on the proper techniques for conducting radiological surveys and monitoring.

LABELING INFORMATION

Patient clothing, drapes, staff clothing, gloves, dressings, and other items used during treatment and decontamination of a contaminated individual should be sealed in double plastic bags and labeled as "Radioactive Waste." At a minimum, the bags should be labeled as to contents; activity levels in cpm, if known; and date, time, and place where the materials were bagged. If possible, avoid mixing biohazards with such items as clothing. Surgical instruments and disposable treatment devices and sharps should be wrapped and bagged separately, and appropriately labeled. Non-porous surgical instruments should not be sterilized for re-use until surveyed for radiological contamination by a qualified individual.

Samples of tissue, body fluids, etc., collected for laboratory analysis during the treatment of a contaminated or exposed patient should be clearly labeled as to their potential contamination and the specific requirements for analysis. Use terms such as "CAUTION- Sample from radiologically contaminated patient." The procedures for handling individual samples in the laboratory may be significantly different than those for samples taken from a non-exposed individual.

FORMS

Essential information about how the patient came to be exposed or contaminated, extent of injuries, present medical condition, and prognosis is vital to determining how best to address the health consequences. Much of the necessary information will be gathered as part of the admissions process and normal patient history development by the doctor or hospital staff.

However, physicians and hospital staff encountering an exposed or contaminated patient need to document additional information relative to the radiological situation as part of the treatment record. Two types of additional documentation are suggested. The first deals with the patient and his condition, and the second with the radiological aspects of the treatment provided.

The information shown on the sample forms accompanying this document may be recorded separately or included within an existing record-keeping system. Most facilities find it more efficient to include such forms with the Radiation Accident Emergency kits described in Section C where they are readily available during an emergency situation.

EMERGENCY ROOM CHECKLIST
for handling
RADIATION ACCIDENT PATIENTS

UPON NOTIFICATION A RADIATION ACCIDENT VICTIM IS ENROUTE:

1. Assemble treatment team and review radiological accident procedures.
2. Gather supplies to maintain isolation area.
3. Assume patient is contaminated; seek monitoring assistance.
4. If possible, determine current "background" level in the treatment area.
5. Contact the Illinois Emergency Management Agency (IEMA).

UPON ARRIVAL OF PATIENT:

1. Treat the medical condition first, using universal precautions.
2. Collect any available information on the radiological exposure/contamination.
3. If possible, survey to determine if the patient is contaminated.
4. If contamination "above background" is present and medical condition permits, attempt decontamination.
5. Bag and retain any contaminated clothing, wipes, gloves and other disposables; label as "Radioactive-Do Not Discard."
6. Survey all medical personnel, ambulance personnel and equipment for contamination.

EMERGENCY ASSISTANCE:

Nuclear Medicine/Radiology: _____

Hospital Radiation Safety Officer: _____

Illinois Emergency Management Agency: 217-782-7860 -- Ask for the Radiation Duty Officer

Refer to the IEMA Medical Guide "Radiation Accidents" for further information and instructions

RESOURCES

Hospitals that anticipate receiving or treating exposed or contaminated patients should consider developing a working agreement or other arrangement with organizations to respond during an emergency by providing expert advice or assistance. However, the immediate assessment and treatment of the patient's medical condition should always be the first priority. Delaying treatment of a medical condition due to concerns about radiological contamination or exposure is seldom, if ever, warranted.

The following is a partial listing of state agencies and other organizations that can provide advice and assistance to medical professionals in evaluating and treating patients exposed to or contaminated with radioactive materials.

1. The IEMA- Division of Nuclear Safety is the agency with statutory responsibility for regulating the use of radioactive materials and other sources of radiation, and investigating incidents of radiation exposure. Contact the department in Springfield 24-hours a day by calling (217) 782-7860.

2. Argonne National Laboratory near Chicago, which is a primary team for the US Department of Energy Radiological Assistance Program, maintains resources to perform radiological monitoring and assessment. To obtain radiological assistance through the Department of Energy, call (630) 252-4800 24-hours a day .

3. Northwestern Medical Center in Chicago has trained staff and facilities to deal with victims of radiological accidents. Contact: Michael Zimmer, Radiation Safety Officer, Department of Radiology (312) 908-2514

4. Loyola University Medical Center in Chicago has an extensive nuclear medicine program with research and consulting capability. Call (708) 216-3777 and ask for the Nuclear Medicine Department.

5. A number of private industrial, manufacturing, and research facilities throughout the state also have trained staff and radiological monitoring equipment available that could be called upon during a medical emergency. The IEMA- Division of Nuclear Safety can assist in obtaining access to these resources upon request.

6. Fire departments in many communities train Hazardous Materials response teams, some of which have the capability to conduct radiological monitoring. In addition, some county and municipal emergency management and disaster services agencies have radiation detection equipment and personnel trained to use it.

7. In the event of a severe exposure situation, expert advice and assistance can be obtained by calling the Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee. This facility, operated by Oak Ridge Associated Universities in cooperation with the U.S. Department of Energy, maintains a 24-hour Hospital Disaster Network information line for radiological emergencies. Call the Radiation Emergency Assistance Center/Training Site (REAC/TS) at (865) 576-3131 or the U.S. Department of Energy Operations Center at Oak Ridge at (865) 576-1005.

8. The Centers for Disease Control (CDC) also maintains a 24-hour Hotline that health care providers can access for advice and support, including technical consultation fro the CDC's Radiation Studies Branch. Call (770) 488-7100.

GLOSSARY

ACUTE RADIATION SYNDROME — Symptoms and signs that are present in a patient who has been exposed to significant whole-body or local radiation.

ALPHA RADIATION — A particulate form of nuclear radiation that consists of a helium nucleus without its electrons. An alpha particle has a charge of +2 and can travel only short distances.

BACKGROUND — The level of ambient radioactivity present in a location or environment at any given time. Levels of radiation are quantified as "above background" to determine potential hazards.

BETA RADIATION — A particulate form of nuclear radiation that consists of an electron. A beta particle has a charge of -1 and can travel millimeters to centimeters in tissue.

CONTAMINATION — The presence of unconfined radioactive material on or within any object where it is not desired.

CPM (COUNTS PER MINUTE) — A standard measure of radiation activity indicating the presence of radiation, as determined with a Geiger-type counting instrument. Contamination readings may also be expressed in terms of millirem or millirem per hour (mR/hr), depending on the type of detection instrument used.

DETERMINISTIC EFFECT — An effect in which the severity of the symptoms are related to the dose of radiation. Example: Acute Radiation Syndrome.

DOSE — A calculated measurement of the amount of energy imparted by ionizing radiation. Dose is relative to the size of the source, the radionuclide or radiation machine involved, and the length of time and circumstances of the exposure.

DOSIMETRY – Devices that measure accumulated, individual dose. These devices are usually worn by workers who handle radioactive materials or work in areas where radiation is present.

EXPOSURE — The irradiation of any object.

GAMMA RADIATION — A form of electromagnetic radiation that is nuclear in origin. It can travel many centimeters in tissue.

GRAY (Gy) — The Systems International (SI) unit of absorbed dose, equivalent to 100 rads or 1 joule per kilogram.

LD_{50} — The absorbed dose required to produce death in 50 percent of the irradiated group. Also expressed as $LD_{50/60,}$ which refers to 50 percent mortality within 60 days.

NEUTRON RADIATION — A particulate form of nuclear radiation. The neutron is an uncharged particle that is released during the decay of high atomic weight elements and is common in nuclear reactions.

RAD — An acronym standing for Radiation Absorbed Dose. An exposure of one rad results in the absorption of 100 ergs of energy per gram of tissue exposed.

STOCHASTIC EFFECT— An effect in which the probability of occurrence is related to the dose of radiation. Examples: genetic defects, cancer.

THERMOLUMINESCENT DOSIMETER (TLD) – An extremely accurate device to measure and provide a permanent record of exposure to radiation.

X-RADIATION — A form of electromagnetic radiation arising from the electron shells of an atom.

Attachment 1-Sample Form-Hospital ER

Patient Information - Radiation Exposure or Contamination

Date: _____ **Time:** _____

Name: _____ DOB: _____ SS# _____

Address: _____

City: _____ State: _____ ZIP: _____

Telephone: Home: _____ Work: _____

Date, Time & Location of Accident or Injury: _____

_____

Nature of Accident or Injury: _____

_____

Description of Injuries/Illness: _____

_____

Type of radioactive material/machine involved (if known): _____

_____

Length of Exposure (if known): _____

How did exposure or contamination occur: _____

_____

Were radiation measurement devices being used (dosimetry, TLDs, monitors, etc.?)

If so, describe type and location: _____

_____

Identify the radiation safety officer responsible for the facility or area where the exposure

occurred, if known. (Name, address, and telephone number): _____

Attachment 2-Sample Form-Hospital ER

Radiological Monitoring and Decontamination Log

Date: _____

Patient's Name: _____ Time of Admission: _____

Monitoring Instrument used: _____

LOG TIMES:

_____ Treatment area background radiation reading (if available and taken prior to patient arrival): _____ CPM.

_____ Initial survey of patient conducted. List area(s) surveyed and readings taken in CPM (counts-per minute):

_____

_____

Indicate areas where readings exceed twice background:

_____

_____

_____

Describe decontamination activity (i.e., washing w/soap and water, sterile flushing, debridement):

_____

CPM of affected area following decontamination:

_____

Attachment 3-Sample EMS Form

Patient Information - Radiation Exposure or Contamination

Date: _____ **Time: _____**

Name: _____ DOB: _____ SS# _____

Address:_____

City: _____State: _____ ZIP: _____

Telephone: Home: _____ Work: _____

Date, Time & Location of Accident or Injury:

_____

_____

Nature of Accident or Injury:

_____

_____

Description of Injuries/Illness:

_____

_____

Type of radioactive material/machine involved (if known):

_____

Length of Exposure (if known):

_____

How did exposure or contamination occur:

_____

Were radiation measurement devices being used (dosimetry, TLDs, monitors, etc.)? If so, describe type and location:

_____

Identify the radiation safety officer responsible for the facility or area where the exposure occurred, if known. (Name, address, and telephone number):

_____

Comments:

_____

_____

_____

Responding EMS Organization:

_____

EMS Personnel Responding:

_____

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