RADIATION ACCIDENTS: GUIDANCE TO THE HANDLING OF OVEREXPOSED INDIVIDUALS

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Incidents and accidents involving exposure to ionizing radiation have become matters of great public concern. This interest has been fueled by media reports, which emphasize not only the devastating horrors of nuclear war, but also seek to enhance fears of cancer epidemic occurring among the survivors. Public at large are fearful of the effects of radiation, especially because of the veil of secrecy that shrouds all activities concerning radiation, and in this climate of public fear, it is the duty of the medical personnel to be able to advise the public in a rational and considered manner. While it is very unlikely that the medical practitioner would be called upon to treat patients who are overexposed to radiation, he should be aware of problems that can arise, so that he can make preliminary assessments, carry out simple treatments and initiate suitable administrative action.

The Association of Radiation Oncologists of India consists of over 700 trained personnel who are adept at handling radiation injury, albeit, localized radiation injury due to their daily involvement in treating patients with radiation. Together with diagnostic radiologists and nuclear medicine physicians, this large group of trained manpower is available to handle radiation accidents as and when the need arises.

The involvement of medical personnel in relation to radiation accidents may be in the following ways:

1) To initiate preliminary treatment following a radiation accident where he is the only available doctor.
2) To provide assistance to occupational or specialist radiological teams in the event of an accident.
3) To be required to attend a conventional accident where it becomes evident at a later stage that radiation factors may be involved.
4) To provide advice and counseling to patients who are fearful of possible radiation effects from nearby radiation installations.

5) To be alert and vigilant to suspicious clinical signs and symptoms that may be radiation related.

For the purposes of developing intervention levels three phases of an accident have been identified, which are generally accepted to be common to all accident sequences- the early, intermediate and late or recovery phase.

The early phase is defined as the period when there is the threat of a serious release, i.e. from the time when the potential for large exposure is recognized to the first few hours after the beginning of a release.

The intermediate phase covers the phase from the first few hours after the start of release to one or more days.

The late or recovery phase is concerned with the return to normal living conditions. It may extend from some weeks to several years after the accident depending on the duration and magnitude of the release.

Whole body radiation at high doses will cause nausea, vomiting and diarrhea, and at higher doses early mortality results due to severe bone marrow depletion. Inhalation of large doses of radioactivity would result in permanent impairment of lung function. Irradiation of the gastro-intestinal tract due to ingestion of large amounts of radionuclides would also lead to early mortality. In nuclear accidents it is the irradiation of bone marrow that has significant fatal consequences. Other non-stochastic effects include impairment of fertility, skin damage and cataracts, but these occur at much lower dose levels.

The stochastic effects following irradiation are either late somatic or genetic. The important late somatic effect is the increased incidence of cancers developing in the irradiated population. The appearance of these cancers is delayed and may be spread over several decades. There is also risk of serious hereditary disease may occur in subsequent generations following irradiation of the gonads.

In addition to the predicted physical health effects of radiation, considerable psychological effects occur, which may constitute significant heath problems. The level of psychological effects is not dependent on the level of exposure.

Medical personnel will rarely be required to deal with acute radiation accidents that may be resultant due to nuclear explosion or meltdown of nuclear power stations. Often the medical practitioner may be called upon to deal with the possible overexposure of radiation amongst personnel who deal with radiation like industrial radiographers. He may also be required to deal with situations where population living in the vicinity of radiation installations may be affected due to chronic radiation exposure. Then there is always the problem of radiophobia wherein patients may approach the medical professional with fears that he has undergone radiation exposure or that certain diseases are a consequence to radiation exposure. These are just some of the situations where a general practitioner may be called upon to give advice and manage patients with radiation related health problems.

RADIATION BURNS

The skin is very vulnerable to external radiation exposure and damage to the skin may result due to radiotherapy or minor accidents involving X and gamma ray sources. Skin damage is dependent on the absorbed radiation dose and the energy of the radiation as well as whether the radiation is electromagnetic or particulate. Dose rate is important and skin effects are likely to be reduced if the exposure is received over a longer period.

Transient Erythema

This usually appears within 2-3 hours of the radiation exposure and is accompanied by a sensation of warmth in the area affected. At very high doses in the excess of 50Gy the symptoms appear very rapidly with the onset of severe pain and a sensation of the affected part being on fire.

Fixed Erythema

In exposure of moderate degree, the transient reddening of the skin lasts only for a short time but reappears in 2-3 weeks and has the appearance of a thermal burn. The length of the latent period is dependent on the total dose and the dose rate. Usually in radiation exposure of moderate degree there is no further progression.

Subcutaneous Injury

The problem with superficial radiation injury is that it may be more severe than it appears due to the fact that with penetrating electromagnetic radiation or energetic β radiation the deposition of energy occurs at a depth and therefore damage occurs in depth. All the important organs in the subcutaneous tissue like the nerve endings, hair follicles, and sweat glands may be damaged; the endothelium of the blood vessels will also be damaged and with passage of time cause an obliterating endarteritis causing overlying tissue necrosis. The pathological effects of radiation burn progress over a considerable period of time. The severity of subcutaneous injury is also dependent on the dose and dose rate, and at levels of 50Gy blistering and skin loss may occur within a very short time. In such cases not only will the subcutaneous tissue be affected but also other internal structures, and in the long term radiation necrosis of the bone, muscle and other internal organs may take place.

Epilation

Loss of hair after a radiation exposure occurs when the dose exceeds 3-4Gy. Epilation usually takes place 2-3 weeks post exposure. Usually hair re-growth occurs with time if the radiation dose is below 7Gy, but with radiation above this the hair follicles are destroyed and the epilation is likely to be permanent.

Management and Treatment of Radiation Burns

No treatment is required for the transient erythema. The mild erythema that occurs 2-3 weeks after radiation exposure also requires hardly any intervention. The skin may become itchy and dry and a bland lotion may be prescribed and the patient is advised not to wear tight or irritating clothing over the erythematous skin. In case of radiation accident, especially when the patient is unaware of the exposure and where no estimates of the dose received are known, the physician may be called upon to treat a patient with signs and symptoms referable to the clinical stages described above. In such situations the time at which the transient erythema appeared and the latent period between the transient and fixed erythema appeared would give some estimates regarding dose and prognosis. Once the fixed erythema stage is reached, demarcation of the exposed area becomes evident, but the underlying extent of damage cannot be estimated with any degree of accuracy.

The indications for treatment of radiation burns, in general, follow the protocol for management of thermal burns. As described in the erythema stage care should be taken to ensure that irritating applications are avoided and only bland lotions prescribed. In later stages dry desquamation of the skin may occur and this is treated with application of 1% aqueous gentian violet. At all stages steroid-containing creams may be of value, but the usual precautions of using topical steroids is to be followed. It is to be noted that ointments in petroleum jelly bases are preferred to cream based ointments.

Radiations burns are accompanied by pain, which may be severe and prolonged. Appropriate analgesics should be used to control the pain. Analgesics that depress bone marrow should not be used. Opoids should be used only when all other analgesics have failed, as the relief of pain may be required for prolonged periods.

Radiation burns may progress beyond the erythema stage to blistering, skin loss and ultimately superficial and deep tissue necrosis. Superinfection is a problem with radiation burns and appropriate antibiotic therapy should be administered.

The combination of pain, tissue loss and infection will probably require surgical intervention at some stage. The precise timing of excisions, amputations or skin grafting is difficult to establish due to the progression of the burn and the attendant bone marrow depression. If the surgical intervention is carried out too early further necrosis may take place, while if it is delayed, the patient suffers. Only specialists trained in the management of radiation burns should take decisions regarding timing and extent of surgical intervention.

EXTERNAL CONTAMINATION BY RADIOACTIVE MATERIAL

Radioactive dusts, liquids or gases may be released to the environment and contamination may occur externally on the skin or internally by inhalation, ingestion or absorption through breaks in the skin. Minor skin contamination may occur from time to time in large nuclear installations, hospitals, research laboratories and industrial laboratories where radioisotopes are used. Patients who are contaminated may pose a potential hazard to those with whom they come in contact due to the possibility of inhalation of radioactive material that has become airborne due to movement or handling of the patient. Movement of a contaminated patient should always be limited to that which is strictly necessary, and prior to movement of the patient some simple procedures such as carefully removing external clothing and washing of the exposed skin be carried out. If the patient is to be moved to a specialist unit, the patient is to be covered with some light non-absorbent material to minimize spread of contamination.

The effects on the skin of radioactive contamination are dependent on the type and energy of the emissions of the radioisotope. Alpha particles are unable to penetrate to the basal cell layer of the healthy skin, the main problem being possible transfer to internal organs. β particles are able to penetrate deeper layers of the skin and depending on their energy to subcutaneous tissue. X and gamma rays are energy dependent with less the energy of the incident radiation; more is the likelihood of skin damage. It is important that before decontamination procedures are started, a person competent to do so should carry out adequate monitoring of the skin.

General Management of Decontamination

In the extremely unlikely event that a general practitioner will be required to carry out decontamination, he will need to take into account the following basic essentials:

a) Careful and detailed monitoring is the first step before any action is taken;

b) If clothing is contaminated, it should be removed slowly, taking care that the deposited contaminants are not made airborne;

c) When carrying out decontamination procedures wear surgical gloves and an apron; in case the contamination is heavy it is better to be wearing complete surgical clothing and mask;

d) All contaminated material, clothing, linen, swabs etc. is to be placed in large impervious plastic bags, sealed and labeled appropriately;

e) Access into patient decontamination areas is limited to authorized personnel only;

f) The patient is to be treated as if he is infected and standard barrier nursing procedures be started.

Formal Decontamination Procedures

These should be carried out in a room earmarked for this purpose. The first step would be to do a complete body survey to demarcate the areas in the body that are contaminated. During the survey any wounds or abrasions should be carefully noted, as these provide direct entry of contaminated material into blood and extra-cellular fluid. If any breaks in skin continuity is noted it should be covered with waterproof adhesive plaster and the wound and the surrounding area should have priority in decontamination. The radioactive substances usually rest on a thin film of oil that covers the outer layer of the skin and the openings of the sweat glands and hair follicles, although isotopes like tritium can penetrate this oily layer and be absorbed through intact skin if the contact period is long enough. Decontamination procedures are based on the removal of this oily film by means of soap and detergents, and only if necessary by the removal of the outer horny layer of the skin by stronger agents. The following steps should be observed:

i) Contamination around the various orifices of the body should be removed, the nose being particularly important;

ii) The contaminants may be removed from other parts of the body taking care to ensure that the absorption of radioactive material into the system has been prevented;

iii) Decontamination procedures must start from the periphery of the contaminated area and move towards the center. Care must be taken to ensure that on no account are contaminated washings being allowed to run onto uncontaminated areas. The procedure should begin with soap and water;

iv) If soap and water fails a weak detergent may be used. Detergent may be used for shampooing the hair if it is contaminated;

v) If the contamination persists then either a saturated solution of potassium permanganate or ordinary household bleach may be used, which removes some of the horny layer of the skin. Extreme care should be exercised and these solutions should not be used near the eyes. The potassium permanganate solution should be left for a few minutes until deep discoloration of the skin occurs. It is then washed off and the skin allowed to dry. The resultant pigmented area is treated with 10% solution of sodium metabisulphite to remove the coloration. If the contamination persists the procedure may be repeated.

vi) In case of small areas of fixed contamination, it could be covered with adhesive plaster and left for a day. The residual contamination will come off when the plaster is removed.

vii) In case the contaminants have not been removed by the methods described above, various other decontaminating agents including chelating agents like EDTA or DTPA may be used.

viii) If all else fails and the contamination is heavy to cause probable damage, then it is necessary to consider removal of contaminated skin by surgical means. Split skin removal is usually sufficient, but if it fails, then full thickness skin removal followed by skin grafting may be required.

Contaminated Wounds and Burns

Any damage to the skin must be identified and covered completely before decontamination. Careful monitoring and assessment of the type and quantity of radionuclide is a must before starting treatment of contaminated wounds and abrasions. Whether surgical intervention is required would depend on the radioactive material embedded in the wound and its physical state. Material that is easily absorbed and transportable may require local and general therapeutic measures. Irrigating the wound and encouraging free bleeding by application of a tourniquet to occlude venous return should commence treatment of a contaminated wound. It may be necessary to enlarge the wound to permit effective irrigation. If such treatment is not sufficient, then a block of tissue containing as much of the contaminants as possible should be removed. While surgical intervention is being undertaken, continuous monitoring of the wound site and any material removed should be carried out. The rationale of removing the block of tissue with the contaminants is to prevent long-term radiation effects. When removing tissue block care should be taken not to damage any of the important anatomical structures. After surgery it is necessary to monitor all the instruments and suitable decontamination procedures followed before the instruments are used again. Dressing used during surgery and after surgery should be collected and assessed for radioactive contamination. In all cases of contaminated wounds and abrasions the collection of urine and feces samples is a must for radiochemical analysis.

INTERNALLY DEPOSITED RADIOACTIVE MATERIAL

The modes of intake of radionuclides may be by ingestion, inhalation or through breaks in the skin. Some radioisotopes like tritium and iodine containing compounds are absorbed directly through intact skin. The hazards posed by each individual radioisotope is dependent on the quantity and site of deposition, the physical half-life of the radioisotope, the type and energy of the emitted radiation, irradiation pattern of the tissues and sensitivity of the tissues to radiation and the metabolism of the particular radioisotope.

Internal contamination consists of four successive stages:

1) Deposition along the route of entry
2) Translocation
3) Deposition in target organs
4) Clearance

General Treatment for Internal Contamination

The two most effective methods of treatment are the blocking of organ uptake by fixation of the radionuclide at the site of entry or trapping in the blood during translocation with re-routing towards a natural excretory mechanism.

Gastro-Intestinal Tract

Radioactive material may enter the gastrointestinal tract either by being swallowed or as a result of inhalation following which material may be swept into the pharynx by bronchial ciliary clearance mechanisms and subsequently swallowed. The type of contaminant is important. If the contaminant is a non-transportable element, insoluble in the gastrointestinal tract, only a small amount will be absorbed and does not usually justify treatment; however if the contaminant is a transportable element, absorbable in the gastrointestinal tract, immediate efforts must be made to insolubilize it. In some cases absorption may take place with subsequent deposition elsewhere in the body or the material may remain in the intestine until it is ultimately excreted; in such cases it is likely that the intestine would be irradiated, more so if there is intestinal stasis. Treatment should be instituted as soon as possible. The general treatment measures are as follows:

a) After a recent ingestion the stomach should be emptied or emetic prescribed

b) A cathartic should be prescribed to cause intestinal movement and minimize the intestinal irradiation

c) Isotopic dilution may be tried, which consists of administration of large quantities of a non-radioactive ion which competes with the radioactive material for absorption

d) Specific therapeutic agents like ion-exchange resins, insolubilising agents, gels and antacids may all be used to reduce absorption of radioactive material from the gut.

Respiratory Tract

The respiratory tract is the most important entry portal for radioactive material from airborne contamination and radioactive gases. Absorption and deposition is dependent on the type of element, its solubility and particle size. For soluble material of particle size of less than 5 μ translocation to the blood and then to the target organ will take place. For insoluble material of small particle size, deposition occurs in the lung parenchyma and direct lung irradiation occurs. For insoluble material with larger particle size deposition in the large bronchi occurs and then ciliary action of the natural clearance mechanisms removes the inhaled contaminant to the pharynx from where it is swallowed.

In case of inhaled materials which are soluble and which may be rapidly translocated to the blood, treatments are directed to trapping the radionuclide in the bloodstream and ensure natural excretion. In case of insoluble radioactive material deposited in the small bronchi and lung parenchyma, treatment is less effective; the use of expectorants and inhaled specific agents are advocated and as a last resort lung lavage may be attempted. Radioactive material that remains in the lung parenchyma is translocated by phagocytosis to the lymphoid channels to the mediastinal lymphnodes.

ACUTE RADIATION SYNDROME (ARS)

This is an extremely rare event and is consequent to exposure of the whole body to very high dose of penetrating external radiation field or to heavy external or internal contamination. The clinical effects in such an accident are dependent upon the time during which the exposure took place, the dose rate, total accumulated dose, and the nature of radiation. In such accidents all types of radiation including neutrons are involved and all of the radiation is delivered at one sudden burst thereby producing the maximum biological effects

Clinical Aspects of ARS

Acute radiation syndrome represents the clinical expression of damage to particularly those organs in which there is a rapid and continuously being replaced. The symptoms and signs would be primarily of the gastrointestinal and hemopoietic system, and treatment is primarily directed to maintenance of fluid balance, the prevention of infection and support of hemopoiesis. In such cases, experience suggests that a dose in the region of 5Gy of penetrating radiation would result in the death of 50% of the exposed population (LD50). The general sequence of events follows a fairly distinctive pattern as follows:

a) Within a few hours of the accident, the Prodromal phase manifests with general malaise, anorexia, vomiting and diarrhea.

b) The Prodromal phase gives way to a latent period of relative well-being which may last up to a few weeks depending on the initial dose. However with exposures of more than LD50 the latent period is considerably reduced and may disappear.

c) Diarrhea, vomiting, severe fluid and electrolyte loss followed by intestinal ulceration and hemorrhage characterize the third phase. The hemopoietic syndrome accompanies this severe gastrointestinal upset with its associated hemorrhages from serous surfaces and infection due to bone marrow deficit.

d) At doses of 50Gy and more, the main effect is on the nervous system, and the patient complains of generalized severe burning sensation along with parasthesiae, rapidly followed by signs of excitement and proceeds to coma and death within 72 hours. Autopsy studies reveal edema of the brain with superficial vessels distended, giving a picture of fulminant encephalitis.

e) Recovery from acute radiation syndrome depends on the exposure and the quality of medical care. With doses of less than 1Gy there is hardly any upset, but at doses between 2Gy and 6Gy, recovery may take a long time, and at higher doses may take several months

Management of Acute Radiation Patient

It is important to get the history of the accident and communication with the appropriate radiological safety officer must be established as a priority. The clinical examination must be detailed and written records must be maintained. Immediate life saving measures must be instituted depending on the severity of the symptoms. The status of each system should be evaluated and detailed records made of all normal and abnormal findings made. The length of time between the accident and the patient being presented to the physician will dictate the clinical pattern of events. Samples of vomit, urine and feces must be collected and sent for radiochemical analysis.

Laboratory Investigations

Taking into account the immediate difficulties associated with dose estimation in nuclear accidents, the results of laboratory examinations of biological material may provide the physician with the only information regarding absorbed radiation dose and following this the immediate and ultimate prognosis for the patient.

Changes in blood picture occur very rapidly after whole body exposure to radiation. The most useful indicator is the lymphocyte count- this is to be repeated every 6 hours for the first 72 hours. Blood grouping and lymphocyte typing should be done. Cytogenetic evaluation should be done and chromosomal aberrations (dicentrics) are estimated, as depending on the frequency of the aberrations, the number of dicentrics in particular, gives a fair estimate of radiation dose. Appropriate biochemistry and bacteriological studies also be performed.

Treatment of Acute Radiation Syndrome

Initially the attending physician would have to deal with nausea and vomiting, which may be due to the whole body radiation or due to anxiety. Steroids, antiemetics, rest and sedation are usually used to manage this. Those patients who have received dose exceeding 10Gy are likely to require only terminal care, efforts being made to reduce symptoms and making the patient as comfortable as possible. In such cases the gastrointestinal symptoms will be the main problem. In doses exceeding 50Gy the main symptoms will be of the central nervous system. Patients receiving doses in excess of 50Gy usually die in about 72 hours.

It is in the patients who receive moderate doses of radiation (in the range of 2-6Gy) that hope of successful treatment lies. Problems that would require to be attended to include fluid-electrolyte balance, hemopoietic dysfunction and infection. The thrust of treatment would be to help the hemopoietic system recover. Transfusion of platelets and granulocytes should be started immediately. Growth factors may be used. If suitable donors are available, then bone marrow infusions may also be considered.

Antibiotic therapy should be started as soon as possible. Antifungal therapy should also be started simultaneously. Some form of barrier nursing should be instituted to prevent infection. Nursing care of the irradiated patients must be of a very high order, as most of these patients would be hospitalized for prolonged periods.

Hospital Emergency Room

All major hospitals should make provisions for the accommodation of radiation exposed or contaminated patients, at least to allow first aid treatment to be undertaken. The facility should consist of a room at the periphery of the hospital with direct access from outside the building. The room should have impervious, easily washable and strippable paintwork, and washable floor with floor drains. An easily cleanable, simple table on which to treat an injured patient should be provided. Showering facilities should be included as an integral part of the room and there should also be a large sink with elbow operated taps set at a height which would allow decontamination of the arms, face and hair to be undertaken. Air movement through the room via air-conditioning should be capable of isolation to minimize the spread of contamination. The drains should be connected to a delay tank before being connected to the main sewer. It is not necessary to purpose-build such a facility and accommodation that is ordinarily used for other purposes may be identified for use as part of hospital emergency plan. Sufficient protective clothing for all staff members should be available and should include surgical scrub suits, coveralls, plastic shoe covers, surgical caps and masks, plastic or rubber gloves and pre-fitted respirators. Also clean, long patient gowns, linen including blankets should be available for patients. Portable radiation detection equipment capable of detecting beta-gamma emissions should be available.

TREATMENT FOR SPECIFIC RADIONUCLIDES

Radioiodine

Treatment consists of administration orally of stable iodine, usually potassium iodide given in tablet form. Treatment should be given as early as possible, but even if instituted 5 hours after intake of radioiodine is usually still highly effective.

Strontium and Radium

These elements are absorbed in the intestine in competition with calcium. It has been found that administration of calcium alginate shortly after ingestion of strontium will partially prevent its absorption. Although alginates also prevent the absorption of radium, they are less effective than in case of strontium. In case of wounds contaminated by these elements, it is worth sprinkling the wound with calcium rhodizonate which precipitates strontium and radium making them insoluble, however treatment needs to be instituted within 15 minutes of the accident.

Caesium and other alkaline metals

There is a continual turnover of caesium and other related elements absorbed from the gut and respiratory system; secretion taking place into the gut and treatment is directed in preventing absorption and reabsorption. This may be achieved by administration of Prussian Blue until no further substantial excretion of caesium occurs.

Tritium

It is absorbed rapidly following ingestion or inhalation and can also be absorbed directly through intact skin. It is easily oxidized to tritiated water. Treatment consists of forced fluid intake and administration of a diuretic.

Plutonium and Other Transuranic Elements

Ingestion of plutonium, a primary alpha emitter, is not a problem, as its absorption is extremely poor. If plutonium is swallowed than a mild cathartic like magnesium sulphate is all that is required. Plutonium contaminated wounds and intake by inhalation pose greater problems as the metabolic pathway of plutonium is related to the solubility or otherwise of the compounds involved. Soluble materials tend to translocate from the lungs to the blood with deposition taking place mainly in the bones and liver. In case of insoluble materials, some of it is removed by ciliary movements to the pharynx and swallowed, while the remaining material is phagocytosed by the macrophages and deposited in the mediastinal lymph nodes. The immediate intravenous administration of DTPA (diethylenetriaminepentaacetic acid) is the preparation of choice for soluble uptakes that forms a complex with the circulating plutonium and is excreted by the kidneys. In case of inhaled contaminants of insoluble nature, intravenous DTPA is of no use since translocation to blood is minimal and chelation will not occur. In such cases administration of DTPA as an aerosol is recommended. If the inhalation is very large, lung lavage may be considered.

Uranium

The danger from uranium is its chemical toxicity to the kidneys. Chelating agents should not be used. Treatment to remove uranium is usually not successful. Intravenous slow infusions of sodium bicarbonate may be tried.

COUNTERMEASURES AND OBJECTIVES OF EMERGENCY PLANNING

Emergency measures designed to reduce adverse health effects are of two types:

- Protective Measures: those that reduce the radiation exposure
- Medical Care: those that reduce the health consequences of accidental exposure (these have been dealt with above)

Some of the potential protective measures that could be implemented include sheltering, stable iodine administration, control of access to the affected areas, evacuation, relocation, control of food and water supplies, personal decontamination and decontamination of areas. The implementation of one or more of these measures will depend upon the nature of the accident, its time phase, specific local conditions such as population size, climatic and meteorological conditions. As a general principle it would be reasonable to implement only those protective measures whose social cost and risk would be less than that incurred by the radiation exposure.

Sheltering

A significant reduction in whole-body and skin doses due to external irradiation can be achieved by remaining indoors during the early phase. Closing windows, doors and other openings and switching off of any air ventilating systems can also achieve a substantial reduction in inhalation dose. The risks and harm resulting from short-term sheltering are low. However, unplanned long-term sheltering can lead to social, medical and psychological problems.

Stable iodine administration

The administration of stable iodine compounds is effective in reducing the uptake of radioiodine by the thyroid gland. It is most effective when ingested prior to or at the time of the exposure, and rapidly loses efficacy if administered a few hours after a few hours, hence it is necessary to ingest the stable iodine as soon as possible when a significant radioiodine release is predicted. Administration of stable iodine is relatively safe, however undesirable but relatively minor side effects may occur in very small proportion of people. It is unrealistic to attempt to distribute stable iodine to the population at risk once a radiation accident has occurred; prior distribution is recommended either to individual dwelling units or to focal points from which the iodine can be made available at short notice.

Control of access

Controlling the movement of people to and from the area affected by the accident will reduce the number exposed and facilitate emergency operations. Difficulties may arise, however, if this countermeasure is in force for some time, as population groups may be anxious to move from or return to their houses. Adequate control must be maintained to minimize risk of traffic accidents.

Evacuation

Evacuation is effective against external and internal exposure, but is a very disruptive procedure and very difficult to implement. This is particularly true when large populations are involved. It should only be applied when absolutely necessary to avoid short-term accumulation of doses and as far as possible to small population groups. It is to be noted that evacuation requires advance planning and there should be sufficient time to implement it, which is only possible if there is sufficient advance notice. A factor to be taken into account will be the private exodus of people from both the affected and unaffected areas.

Relocation

Relocation is implemented to avoid long-term high doses from the ground deposition of radionuclides. It is expensive and is dependent on the availability of adequate safe area.

Control of food and water supplies

Food control may entail destroying of contaminated foodstuffs or restriction or banning their consumption, delaying their consumption by converting them to other products, or storing them until activity decreases to an acceptable level. Control of water supply usually entails prohibiting the use of water from a contaminated source. Such measures may cause other problems in areas where there is already a shortage of food and water.

Personal decontamination

Personal decontamination should be undertaken only when there is strong evidence or suspicion of body surface contamination. Domestic showers are adequate for decontaminating the skin, and most contamination of clothing can be removed by laundering. Medical assistance may be required if there are contaminated injuries or where repeated washings cannot remove contamination. The only risk from personal decontamination is that of spreading radioactivity to previously uncontaminated areas.

Decontamination of areas

This protective measure involves the removal of contamination from the affected area to another location that is less hazardous. It may consist of washing, vacuum-cleaning surfaces, ploughing agricultural land or removing surface layer of soil. These measures are effective in reducing external radiation from deposited radioactivity and in restricting internal doses from the inhalation of resuspended radionuclides. The risk is to those who are exposed in performing the procedures.

This article does not attempt to be a comprehensive guide for emergency medical response to a radiation accident. This article has only outlined the general principles for guidance of medical personnel in the unlikely event of his being called upon to assist in the handling of radiation accident.

Suggested Further Reading:

1) A guide to the hospital management of injuries arising from exposure to/or involving ionizing radiation. Chicago, American Medical Association, 1984.

2) Manual on early treatment of possible radiation injury. Vienna, International Atomic Energy Agency, 1978 (IAEA Safety Series No.47).

3) Management of persons accidentally contaminated with

radionuclides. Washington D.C., National Council on Radiation Protection and Measurements, 1980 (NCRP Report No.65)

4) Manual of protective action guides and protective actions for nuclear incidents. Washington D.C., US Environmental Protection Agency, 1980.