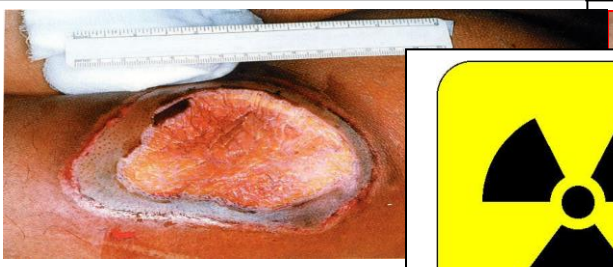
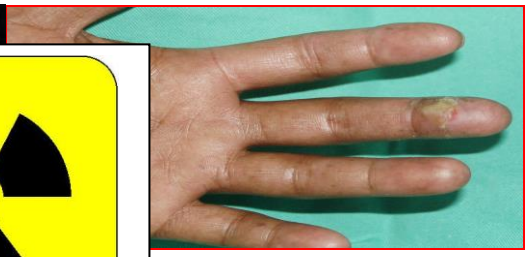
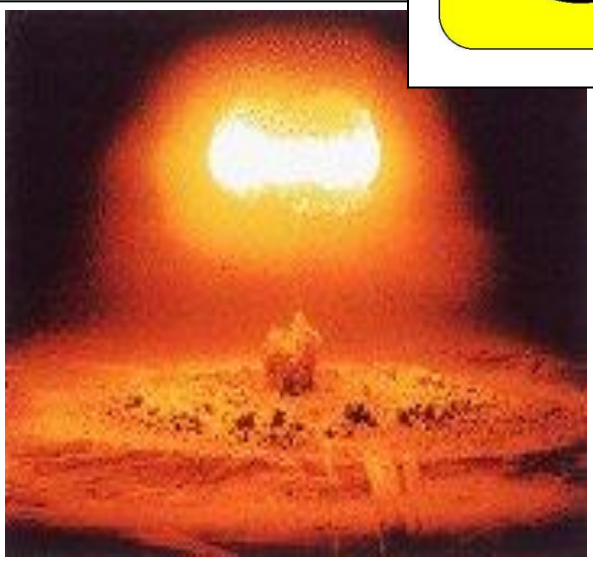
MEDICAL RESPONSE FOR RADIATION EMERGENCY

HOSPITAL KUALA LUMPUR

2017 EDITION







“The release of atomic energy has not created a new problem. It has merely made more urgent the necessity of solving an existing one.”

Albert Einstein

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1.0 INTRODUCTION

1.1 INTRODUCTION

The mission statement for the Ministry of Health (MOH) in response to radiation emergency is as follows: -

"In the event of a radiological emergency, the Ministry of Health will be responsible for providing appropriate medical care to radiological victims both on-site and in the hospital. The Ministry of Health will also be responsible for monitoring long-term health problems that could arise as a result of complications from the radiological event. The Ministry of Health will be able to mobilize the necessary personnel, laboratory and radiological resources for the purpose of deployment during emergencies".

According to Prime Minister's Directive 20 of the National Security Council, the leading technical agency for any radiation emergency will be the **Atomic Energy Licensing Board (AELB).** The MOH will be responsible for **providing medical care to the victims** while the control of environmental spread of radioactive substances, assessment of its impact on the environment, food and water supplies, properties and the initiation of protective measures for these items will be the responsibility of the **AELB.**

1.1.1 RADIATION RISK IN MALAYSIA

Malaysia has one small research nuclear reactor in Bangi, Selangor which has only 1 Megawatt capacity. Radioactive materials are used for therapeutic purposes in Radiotherapy & Oncology and Nuclear Medicine Departments. For example Cobalt-60 and Iodine-131 are used widely in these units. Local industries also utilize radioactive materials.

It is also known that nuclear-powered ships ply Strait of Malacca and these ships may have high capacity which is equivalent large nuclear reactors. Therefore, one way or another, appropriate preparedness efforts should be started and improved with time. Malaysia is also surrounded by large nuclear reactors in the Philippines, Indonesia and Thailand. Some of these reactors are old with dubious safety standards. Therefore the risk of radiation emergency should not be taken lightly in Malaysia.

1.2 OBJECTIVE

The objective of this guideline is to provide a plan of action for **Hospital Kuala Lumpur** in dealing with radiation emergencies. Although it will not be possible to discuss the specific details as this will depend on the scale of events and the type of radioactive substances involved, guidelines on the emergency treatment of radiation victims both on site and in the hospital will be outlined.

1.3 TYPES OF RADIATION ACCIDENT

Radiation accident can arise from problems with nuclear reactors, industrial sources and medical sources. Although there are some differences between the various types of accidents, there are elements common to all of them. Classification of radiation injuries could be summarized in the table below:

1.3.1 CLASSIFICATION OF RADIATION INJURIES

Table 1.1: Classification of Radiation Injuries

EXTERNAL EXPOSURE	***The body is exposed either partially or wholly to radiation source but none of the materials is on (or within) the body***
CONTAMINATION	***The radiation source is carried by the victim. This may be found externally (on skin, hair, wounds etc) or internally (ingested, inhaled or absorption through wounds)***

1.3.1.1 External Exposure Vs Radiation Contamination

Regardless of where the accidents occur, there are two categories of radiation accidents: ***external radiation exposure***, which is irradiation from a source distant or in close proximity to the body; and ***contamination***, defined as radioactive material found in or on the body.

1.3.1.2 External Radiation Exposure

Almost all industrial accidents, most reactor accidents, and many medical accidents result in irradiation of the victim. There may not be direct contact between the victim and the radiation source, which may be a radiation-producing machine (like the X-ray or CT SCAN) or radioactive source materials. Once the person has been removed from the source of radiation, or the machine emitting radioactive rays has been turned off, the irradiation ceases. The ***victim is not a secondary source of radiation*** and individuals providing support and treatment are in no danger of receiving radiation from the victim. **A person exposed to external irradiation does not become radioactive and is not a hazard to nearby individuals.**

1.3.1.2 (a) EXPOSURE: WHOLE BODY & LOCAL

External **irradiation** can be divided into: **whole-body exposure** or **local exposure**. In either case, the effective dose can be estimated, taking into account the attenuation of the body and the steep gradients of absorbed dose throughout the body.

1.3.1.2 (b) CONTAMINATION

Contamination requires an entirely different approach to the care and treatment of the victims. Contamination may be in the form of *radioactive gases, liquids or particles.* Caregivers and support personnel must be careful not to spread the contamination to uncontaminated part of the victim's body, themselves or the surrounding area.

Internal contamination can result from inhalation, ingestion, direct absorption through the skin, or penetration of radioactive materials through open wounds.

1.3 TYPES AND PROPERTIES OF RADIATION

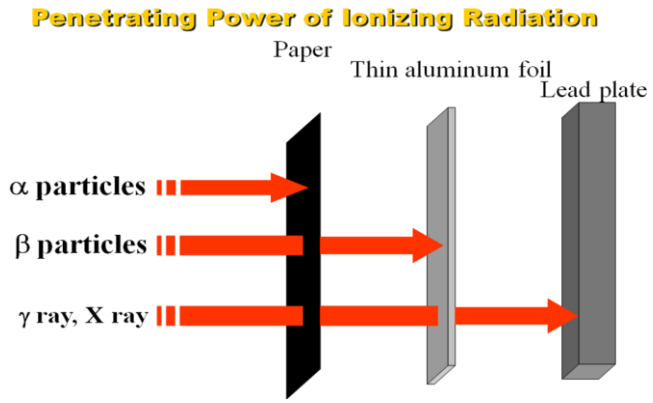

Figure 1.1: Types and Properties of Radiation

Ionizing radiation is an electromagnetic and/or particulate in nature and mainly of 3 types. **Alpha particles** comprise of two protons and two neutrons and are identical to the nucleus of the helium atom. These particles demonstrate poor penetrating power and are easily stopped by the thin outer layer of the skin. The **beta particles** originate from neutron to proton conversion, from ejected orbital electrons or conversion of photon to charged particles (either to electron or positron). The beta particle has a slightly higher penetrating power than the alpha particle but this range is only a few centimeters in soft tissues. The **gamma ray** (identical to X-ray) is different from the above two particulate radiations in that it has a far greater penetrating power and it is a photon without mass and charge. Gamma rays are electromagnetic radiation of high energy, originating in atomic nucleus and accompanying many nuclear reactions including fission and radioactive decay. Gamma rays are the most penetrating type of radiation and represent the major external hazard.

Exposure to different types of radiations produces different types of injuries because of the different properties of the radiations. The magnitude of

risk upon an exposure is also different. For example exposure to alpha and beta particles does not pose significant threat to life due to its short distance of emission, but hazardous if improperly handled; e.g. when it is inhaled or ingested or deposited into the tissues. Adequate knowledge of the source materials, proper handling and monitoring should be available whenever substantial alpha sources are present. Exposure to a high dose of beta radiation will "burn" the skin. Inhalation or ingestion of beta sources will lead to tissue damage. In contrast, the high penetrating power of gamma rays with its predictable effect, depending on the dose and the area of the body or part of organs exposed, constitutes a radiation risk to the exposed person. Therefore specific protective measures should be given to this type of radiation.

1.4 RADIATION MONITORING OF RADIOACTIVE MATERIALS

1.4.1 ALPHA RADIATION MONITORING

Alpha particles travel only a ***few centimeters in air*** and up to ***40 micrometer (μm) in tissue***. As such they cannot penetrate the cornified epithelium. The low penetrating power of the alpha particle therefore dictates that alpha survey must be accomplished with thin window probes, minimal absorbing material between the detector and source and a limited physical distance between the probe and surface monitored.

1.4.2 BETA AND GAMMA RADIATION MONITORING

A number of radionuclides decay by beta and gamma emission although some pure beta emitters exist. The principles used for beta and gamma monitoring are similar to those used for alpha monitoring. However, beta and gamma radiations travel much greater distances in air and tissue when compared to alpha radiation.

Their greater penetrating power makes for easier detection in accidents. ***Monitoring should be slow and methodical*** as with alpha monitoring. The probe can be held about **one inch** from the surface

monitored and may be **covered with a plastic or rubber glove to prevent contamination of the probe and subsequent false reading.**

2.0 PLACES AT RISK FOR RADIATION ACCIDENT

2.1 PLACES AT RISK FOR RADIATION ACCIDENT

Medical provider must be prepared to adequately treat injuries complicated by ionizing radiation exposure and radioactive contamination. Risk assessment should be made based on the site of radiation sources.

The possible places where radiation accidents can take place in Malaysia:-

i. In reactor facilities, in the Malaysian context there is only one low capacity reactor in Malaysian Nuclear Agency (formerly known as MINT) in Bangi.

ii. In factories, work places and research centers involving the usage of radiation and radioactive substances.

iii. In hospitals where there are facilities for radioisotopes and radiation services. These include primary isotopes used in:

a) Nuclear Medicine Department

^{99m}Tc, ^{131}I, ^{68}Ga, ^{51}Cr ^{137}Cs, ^{90}Y, ^{177}Lu

b) Radiotherapy & Oncology Department

^{60}Co, ^{192}Ir, ^{125}I, ^{46}Pd

** Types of radiation emitted by the decay of the above radionuclides and their half-life are shown in Appendix 2.*

IV. During the transportation of radioactive materials, accident can occur anywhere along the path of transportation.

v. Radiation can take place in extraneous sources, i.e. mishaps which take place in other countries, but has an impact on Malaysia such as atomic plumes carried by clouds to country's shores.

vi. From satellites with nuclear materials. This is a special type of emergency in which a spacecraft with nuclear materials land in any territory within Malaysia.

3.0 NOTIFICATION AND IMMEDIATE ACTIONS

3.0 INTRODUCTION

The existing organization in the Ministry of Health (MOH) both at the periphery and central levels will be involved in the process of notification and response to radiation accidents. The **National Radiation Emergency Committee** is a national committee whose members comprise of staff from various government bodies and representatives from the MOH. The other committee within the HKL itself is known as the **Radiation Emergency Treatment Committee (RETCOM)** for medical assistance.

3.1 NOTIFICATION OF RADIATION ACCIDENT

3.1.1 EXTERNAL RADIATION ACCIDENT

3.1.1.1 RESPONSIBILITY OF NUCLEAR INSTALLATION PREMISES

- In any premise that uses radiation or any nuclear installation, it is the responsibility of that premise to inform the nearest hospital and request for medical assistance when an accident has taken place.
- It is to be emphasized here that prior arrangement with the nearest hospital is needed if there is a possibility of mishap particularly in places where high dose or high-energy radioactive materials are used.
- This will assist in the provision of facilities and emergency preparedness in the hospital.

3.1.1.2 THE RADIATION PROTECTION OFFICER (RPO)

- In every premise there should be at least one person that will be responsible for radiation safety, referred to as the **Radiation Protection Officer (RPO).** The **RPO** should have adequate qualification or have some training in radiation safety.
- In case of a radiation accident, the **RPO** should immediately inform the district medical officer and the hospital director of the nearest hospital to assist in the preparations to receive

patients. At the same time he has to contact **AELB** to request for further advice and help.

3.1.1.3 NOTIFICATION AND ACTION PATHWAY OF EXTERNAL INCIDENT

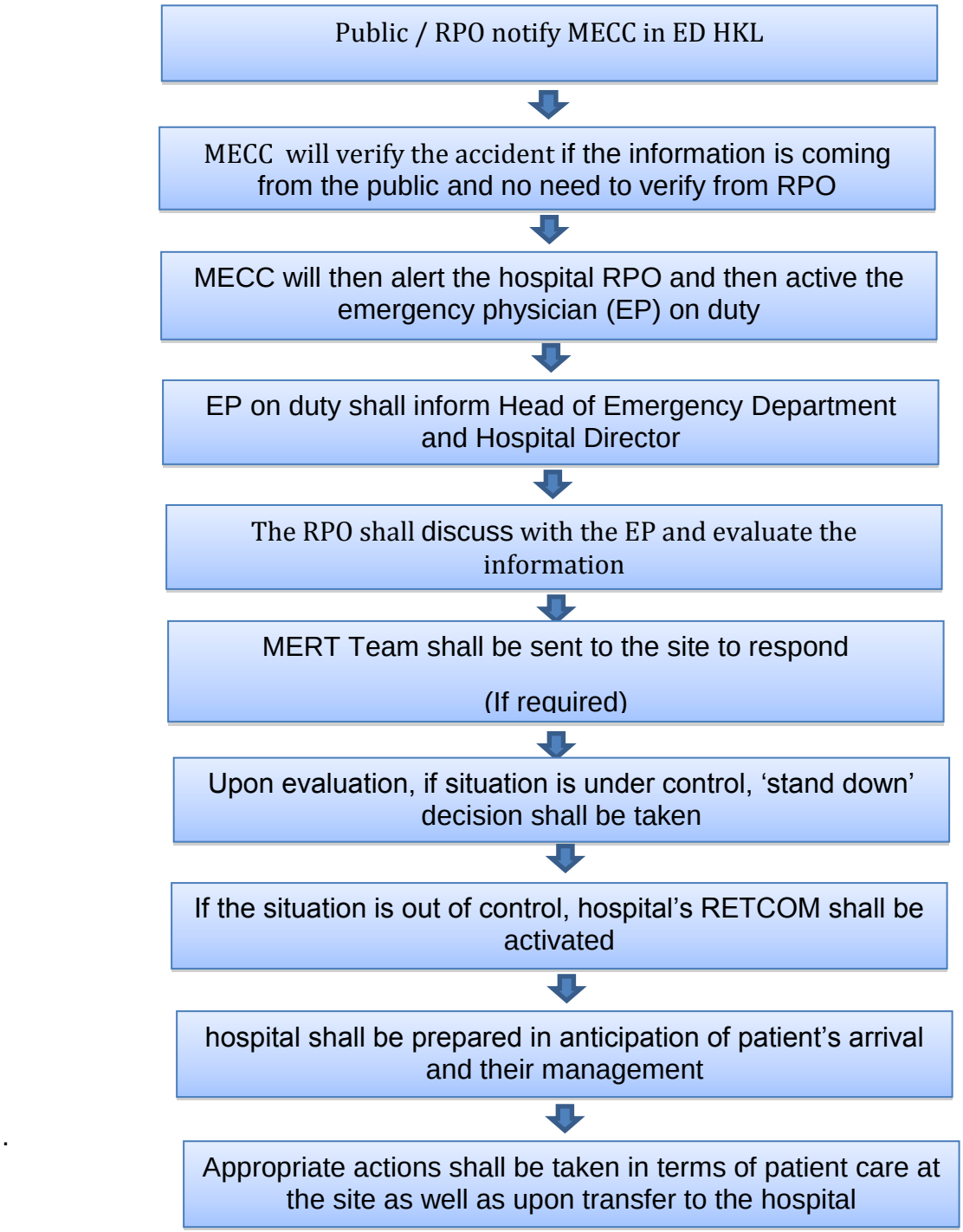

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Figure 3.1: Notification and Action Pathway of External Incident

- When an accident occurs, either the public or the premise RPO (or representative) will notify HKL Medical Emergency Co-ordinating Centre (MECC) in Emergency Department (ED) HKL.
- The HKL MECC will verify the accident if the information is coming from the public but no verification required if the information comes straight from the premise's RPO.
- The HKL MECC will then alert the hospital RPO and the active emergency physician on duty (EP).
- The EP on duty shall inform the Emergency Department Head of Department and the Hospital Director.
- The RPO shall discuss with the EP and evaluate the information.
- If required a MERT Team shall be sent to the site to respond.
- Upon evaluation, if situation is under control, 'stand down' decision shall be taken.
- If the situation is out of control, hospital's RETCOM shall be activated. In such situation, hospital shall be prepared in anticipation of patient's arrival and their management.
- Appropriate actions shall be taken in terms of patient care at the site as well as upon transfer to the hospital.

3.1.2 INTERNAL RADIATION ACCIDENT (WITHIN HOSPITAL KUALA LUMPUR)

3.1.2.1 NOTIFICATION AND ACTION PATHWAY OF INTERNAL INCIDENT

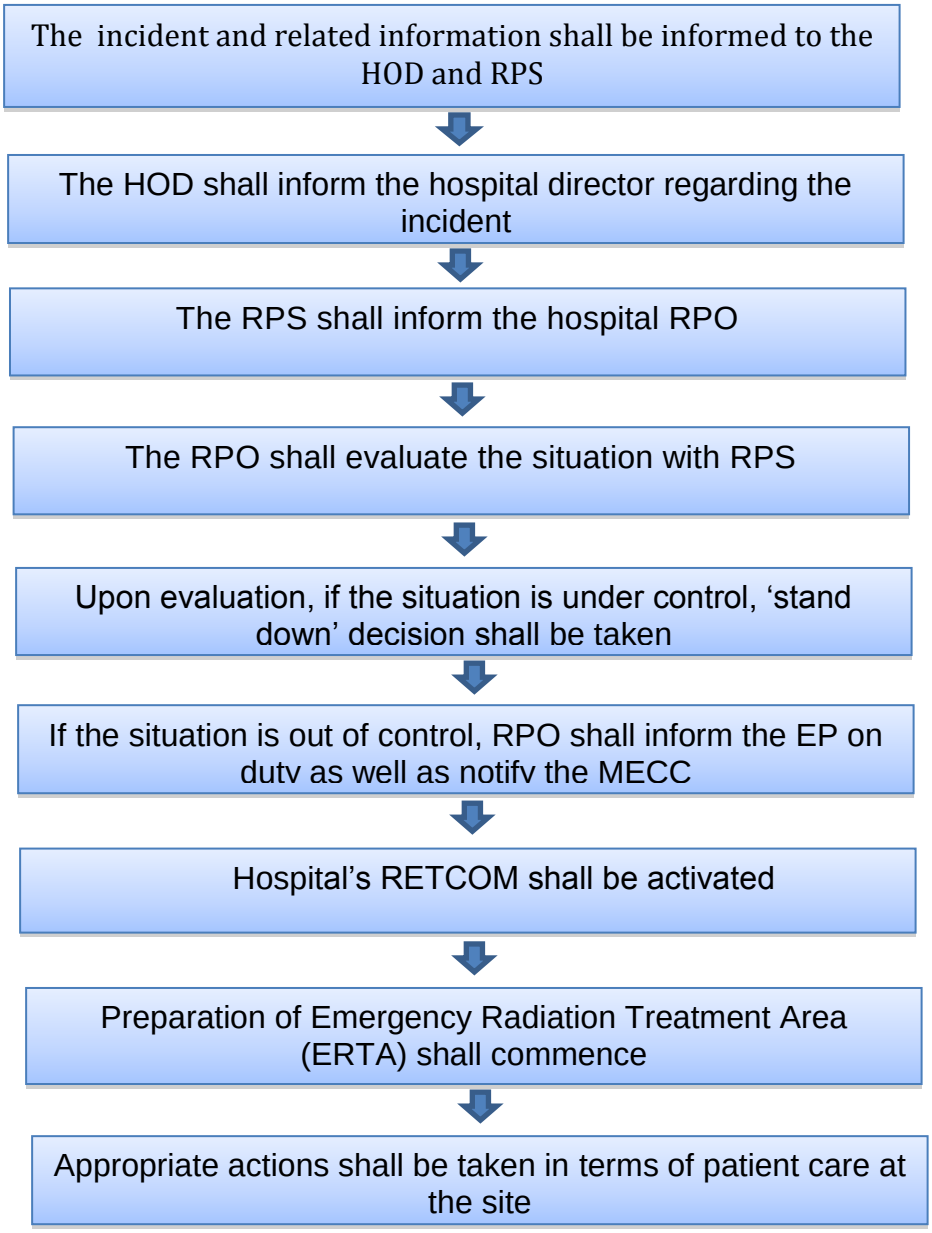


Figure 3.2: Notification and Action Pathway of Internal Incident

- If the incident occurs within HKL, the incident and related information shall be informed to the department's organization head and the department's RPS.
- The HOD of the department involved shall inform the hospital director regarding the incident.
- The RPS shall inform the hospital RPO.
- The RPO shall evaluate the situation with RPS.
- Upon evaluation, if the situation is under control, 'stand down' decision shall be taken.
- If the situation is out of control, RPO shall inform the EP on duty as well as notify the MECC.
- Hospital's RETCOM shall be activated.
- Preparation of Emergency Radiation Treatment Area (ERTA) shall commence.
- Appropriate actions shall be taken in terms of patient care at the site

3.1.2.2 ROLE AND FUNCTION OF OPERATION PERSONNEL IN THE ACCIDENT AREA (FOR INTERNAL ACCIDENT)

The organizational functions during internal accident are very much like the system used in the event of fire. The roles of floor marshal, Emergency Manager, Accident Controller, Security Controller, Evacuation Controller and Medical Controller are illustrated below:

Table 3.2: Role and Function Of Operation Personnel In The Accident Area (For Internal Accident)

NO	ROLE	PERSONNEL INVOLVED	FUNCTION
1	Emergency Manager (EM)	HOD OF Department Involved	• Oversees overall activities to handle radiation emergency or any related accident (e.g. fire, explosion, etc.)
2	ACCIDENT Controller (IC)	RPO	• To control the accident • Ensures control area established for contaminated and non-contaminated zones. • Advises EM for measures to be taken in order to control situation. • Undertakes appropriate measures to handle situations (e.g. ensuring PPE worn by personnel, putting out fire, controlling entry and exit etc.) • Assisted by RPS and Chief of Supervisor of affected unit.
3	Security Controller (SC)	Polis Bantuan	• Ensures security of area • Control the crowd (personnel, patient and public) • Control the safety of area • Control traffic
4	Evacuation Controller (EC)	Area Matron	• Oversees evacuation process if required • Assisted by sister in charge of the affected unit
5	Medical Controller	Specialist or Medical Officer in charge of the affected unit	• Ensure the medical well-being of affected patient or injured personnel. • Provide medical treatment while waiting for medical assistance to arrive.
6	Floor Marshall	Unit Supervisor	• Responsible to give direction to staff and patients in the event of evacuation • Will be in-charge at the unit affected to oversee a smooth and controlled process of evacuation

3.1.2.3 NOTIFICATION OF INTERNAL INCIDENT

Upon evaluation by RETCOM, the RPO shall ensure that the following be informed:

- Hospital Public Relation Officer (PRO)
- Occupational Safety & Health Unit, HKL
- *Bahagian Kawalselia Radiasi Perubatan (BKRP)* in Putrajaya
- *Bahagian Kesihatan Awam, KKM*
- AELB emergency team

3.2 RADIATION EMERGENCY TREATMENT COMMITTEE (RETCOM)

A Radiation Emergency Treatment Committee (**RETCOM**) is formed at Hospital Kuala Lumpur in preparation for radiation emergencies. **RETCOM** consists of representatives from various departments and units in the hospital.

This committee shall come from existing Hospital's Radiation Protection Committee. This committee will automatically become the RETCOM team during radiation emergency situation.

The functions of this committee are:

i. As an advisory committee.
ii. It ensures the establishment of Radiation Emergency Response plan to be in place and updated
iii. The members can be called at any time during radiation emergency situations to provide guidance and advice
iv. It also provides necessary advice and guidance to the **Medical Emergency Response Team (MERT)** which delivers emergency care to victims at the site of the accident **if necessary**.

3.3 THE MEDICAL EMERGENCY RESPONSE TEAM (MERT)

MERT is the team sent from the hospital to the incident site to provide medical assistance. This team can also be sent to the incident site within hospital compound in the event of internal incident.

The team consists of:

1. Radiation Protection Supervisor(RPS)
2. Specialist or medical officer (leader)
3. Staff Nurse
4. Assistant Medical Officer
5. Health Attendant
6. Driver

Apart from the RPS, the ambulance team will come from the Emergency Department. However if there is a need to send more teams, personnel from other departments will be mobilized.

3.4 ROLES OF THE EMERGENCY PHYSICIAN ON DUTY DURING THE ACCIDENT:

1. Inform the Head of the emergency department who will subsequently inform the hospital director.
2. Instruct the Emergency Department's Supervisor to open Operations Room in emergency department.
3. Instruct ED AMO to prepare and assemble the medical emergency response team (**MERT**).
   a. **MERT** will consist of yellow zone ED doctor, ED AMO, Staff nurse (S/N), health attendant *(Pembantu Perawatan Kesihatan-PPK),* Radiation Protection Supervisor (RPS) and a driver.
   b. The RPS following the team will be instructed by HKL's RPO
   c. **MERT** will roll out and put on PPE. The team will be sent to the site for response upon instruction by EP on call.
4. Facilitate and supervise preparation for management of patients.

3.5 ROLES OF THE RPO DURING THE ACCIDENT

1. The RPO heads all RPS and can give any instructions to any of the RPS
2. RPS can be instructed to necessary areas (eg. Follow the MERT; be stationed at the triage area, Emergency Radiation Treatment Area (ERTA)/decontamination room, *Bilik Gerakan* etc.)
3. RPO provides radiation safety advice to be followed by all.

3.6 OPERATIONS ROOM (BILIK GERAKAN)

Operations room will be opened and, depending on the needs the people to be called can be either members of the RETCOM or if the accident involves mass casualty accident the call list according to Red Alert protocol of HKL Emergency Response Plan is to be followed.

RETCOM will oversee, complement and advise on actions taken for the management of patient. **RETCOM** will prepare report regarding current and after event. During the response phase, the **RETCOM** will form an organization in line with the Mass Casualty or Disaster Management Command System.

3.7 ORGANIZATION CHART DURING RESPONSE OF RADIATION INCIDENT

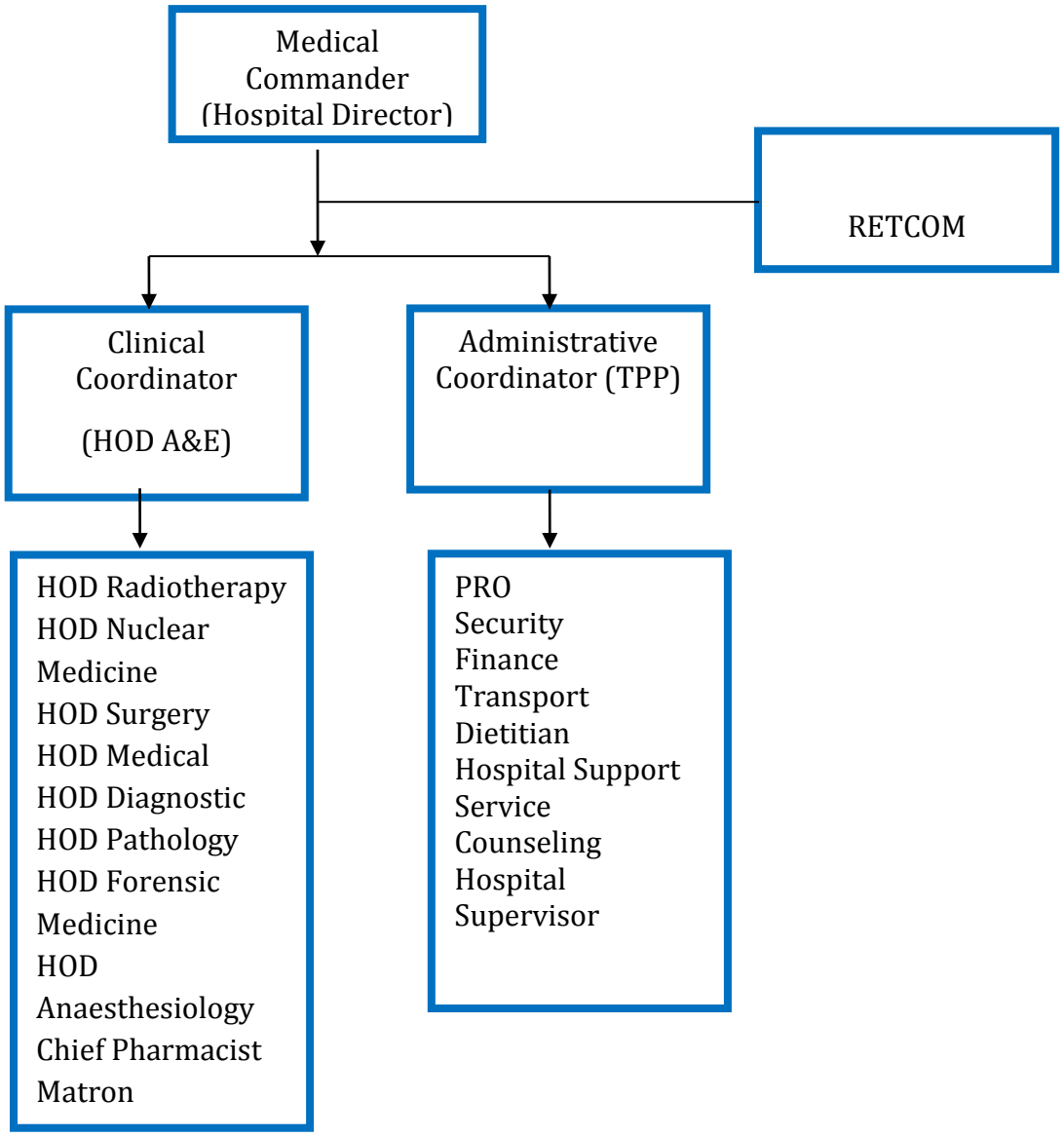


Figure 3.3: Organization Chart during Response of Radiation Incident

3.8 MANAGING PATIENTS ARRIVING AT THE EMERGENCY DEPARTMENT

All personnel, upon notification must wear full Personal Protection Equipment (PPE). This PPE is no different from the ones used in biological incidents and includes head cover, goggles, mask, gown, apron and shoe cover.

When patient arrives, patient will be screened by the Radiation Protection Supervisor – RPS.

3.8.1 PATIENTS; EXPOSURE VS CONTAMINATED

Patients who only have radiation exposure but not exposed are managed in area similar to other normal patients. These patients will test negative on survey meter screening by the RPS. They pose no danger to personnel as they do not emit radiation and therefore need no isolation.

Contaminated patients (or status not known) are managed in Emergency Radiation Treatment Area (ERTA). These patients will test positive on survey meter screening by the RPS. This area is an isolated area and normally, the decontamination room of Emergency Department is used for this area. The decontamination room has to be prepared before use.

The RPS shall determine whether patient is exposed or contaminated.

3.8.2 THE DISTANCE, TIME & SHIELD (DTS) PRINCIPLE

The principle of management in any radioactively contaminated patients is 'DTS' i.e. **D**istance, **T**ime and **S**hield. To ensure safety, the measures taken will fall into these three categories:

3.8.2.1 Distance

- Determine safe distance via calculations performed by Physicists.
- A safe area therefore could be established following the recommendation by Medical/Health physicist.

3.8.2.2 Time

- When medical personnel have no choice but manage the patient in close range, the time allowed can be calculated by a physicist.
- A ‘personal dosimeter’ i.e. a gadget to determine the radiation dose of medical personnel can help determine the total dose received. If available, this can be used.
- People can take up radiation but to a limited dose over a period of time. Ordinary people are all exposed to radiation from the background natural sources and the average dose from this is 300 milirem (3mSv) a year.
- For workers (which includes medical personnel), the limit is set to be 2000 milirem (20mSv) a year.
- For non-radiation workers, limit of radiation dose is limited to not more than 1mSv per year.
- Calculations can be made to determine the time limit for personnel based on the dose rate of the radiation source, taking into account the allowed radiation dose while handling the patient.

3.8.2.3 Shield

- Depending of the types of radiation, types of protection differs. For Alpha ray, a piece of paper is can stop the radiation. For Beta rays it is stopped by a piece of aluminium foil. Nevertheless, Gamma rays, although reduced are not stopped totally by lead shield.
- Medical personnel may use barrier-nursing principle to handle patients.
- The approach should be similar to the ones used to handle infectious diseases.
- Similar personal protective equipment (head cover, goggles or face-shielded mask, surgical mask, gown, apron, boots and shoe cover) may be used.

3.8.3 EMERGENCY DEPARTMENT DECONTAMINATION ROOM FOR RADIATION INCIDENCE

Upon instruction by Emergency Physician on-duty, Hospital RPO or ED AMO will inform ED sister in-charge to prepare decontamination room.
Hospital RPO will supervise the ED sister in-charge in the management of the decontamination room in ensuring the establishment of the following:

1. Triage counter
2. Plastic sheet to cover flooring
3. Covered trolley
4. Lead box ready to use
5. Emergency doctor from **Room 3 of the Emergency Department** to standby to examine patients with full PPE.
6. Relevant department to standby

3.8.4 EXAMINATION OF PATIENT

If the patient is contaminated and decontamination is not done yet, patient is examined at the Emergency Radiation Treatment Area (at decontamination room). During examination the following will be taken:

1. Vital signs
2. History and clinical examination
3. Blood examination (Full blood count with differentials, Renal Profile, Liver Function Test, Thyroid Function Test, Blood for bio dosimetry)
4. Excreta for bio dosimetry

3.8.5 ROLES AND RESPONSIBILITIES OF PERSONNEL INVOLVED

Table 3.3: Roles and Responsibilities of Personnel Involved

PERSONNEL	FUNCTION
Medical Commander (Hospital Director)	Oversee the overall hospital response operation.
Clinical Coordinator (HOD Emergency	Coordinate clinical activities.

Department)	
Administrative Coordinator (Deputy Director of Hospital)	Coordinates hospital response and assures normal hospital operations (TPP).
Head of Departments (HOD)	Support clinical needs and expertise
Radiation Protection Officer (RPO)	Leads in technical advices and assists coordination.
Emergency Doctors/ physicians	Diagnose, treat and provide emergency medical care; can also function as team coordinator or triage officer.
Radiation Protection Supervisor	Surveys and measures the contamination (RPS 1).
Triage officer	Performs triage.
Nurse	Assists physician with medical procedures, collection of specimens, radiological monitoring, and decontamination, assesses patient needs and intervenes appropriately.
Technical recorder	Records and documents medical and radiological data (RPS 2).
Public Relation Officer (PRO)	Manages media needs and releases information to public and media based on Hospital Director's instructions.
Chief Pharmacist	Provides pharmaceutical support
Dietician	Provides food with disposable utensils for patient and emergency team.
Counsellors (Medical Social Workers and Clinical Psychologists)	Provides psychological and emotional support.
Hospital support service (Radicare)	Provides maintenance support
Finance Officer	Provide emergency financial support.
Security personnel	Ensures security at the radiation emergency

	area and controls crowds.
Maintenance Personnel	Aids in preparation of the radiation emergency area for contamination control (RPS 3).
Laboratory technician	Provides routine clinical analysis of biologic samples/specimen.
Forensic	Proper handling of deceased body.

3.8.6 SETTING UP OF EMERGENCY RADIATION TREATMENT AREA

Hospital Kuala Lumpur is the designated National Radiation Treatment Centre. Therefore it requires **Emergency Radiation Treatment Area (ERTA),** equipped with facilities for the treatment of victims from radiation emergencies. This centre is to be used as a place for the decontamination of certain patients; particularly heavily contaminated victims. In the instance where the contamination status is unknown, it should be treated as "contaminated" and also be treated in the **ERTA** until the RPO confirms the status. Currently the decontamination room at HKL's Emergency & Trauma Department is being used for as the designated ERTA.

Ideally, the **ERTA** should be large enough to accommodate the anticipated number of injured and contaminated radiation victims and medical personnel. It should be away from the main traffic flow of the hospital, yet has direct access to facilities in emergency department i.e. to cardiac monitor, defibrillation machine, resuscitation trolleys and medication etc. and a controlled access to the outside. The area should preferably be equipped with hot and cold water, floor drain, walls that are easily washed and if possible shower facilities.

With the advent of industrialization in Malaysia and wider use of radioactive materials throughout the country, it is proposed that the ERTA should be widened throughout the nation. All major hospitals in every state should be equipped adequately with all facilities to cater for

decontamination services. Post decontamination, these patients could be nursed with barrier nursing in isolation wards **(ward 28 in HKL)**

3.8.6.1 SET-UP OF EMERGENCY RADIATION TREATMENT AREA (ERTA)

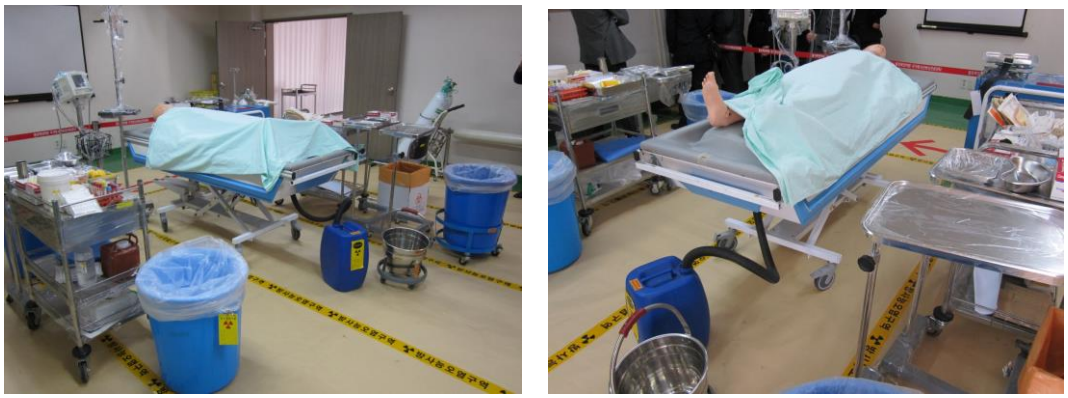


Figure 3.4: ERTA has floor covering. The decontamination is done by removing all patient's clothes and water & soap used to clean locally contaminated area. The effluent is collected into a tank

Figure 3.5: Emergency Trolley is available and adequately covered with protective layer

Figure 3.6: Decontamination team: wearing full Personal Protection Equipment (PPE**)**

Figure 3.7: A dedicated staff to take samples for investigation

Figure 3.8: Decontamination facility for medical staff

3.8.7 HANDLING MASS CASUALTY RADIATION INCIDENTS AT THE HOSPITAL

If a large number of victims from an area of radiation accident comes to the hospital without any warnings, mass screening will be conducted at the ambulance bay (at the back portion of HKL's Emergency & Trauma Department). If the number is too large, the screening process will be done at HKL's football field.

Upon screening, victims will be divided to 'exposure' and 'contaminated' group. Those who only had exposure will be seen by medical personnel without need of decontamination. The screening is conducted by RPS upon instruction by RPO at the said site(s).

For those who are in 'contaminated' group, they will be decontaminated using mobile decontamination facilities. The mobile decontamination unit will be set up at the ambulance bay of the Emergency Department. If patients who could be completely decontaminated, they will may be placed in normal wards for admission. If the status of contamination of patients could not be ascertained or patients could not be completely decontaminated, admission

will be to the assigned isolation ward (ward 28). If the number of patients outnumbers the bed in ward 28, adjacent ward will have to be cleared to cater for patients. RPO can also advise as to whether patients could be put in the same ward with safe distance from one another based on the radiation types and dose.

If the number of those ‘contaminated’ is too high, assistance from Hazardous Material (HAZMAT) unit from Fire and Rescue Services will be sought after. For this, the Fire and Rescue Services may set up its services on the football field.

All patients must be rescreened after decontamination processes. Hospital garments must be made available as all clothes had to be removed in the decontamination process.

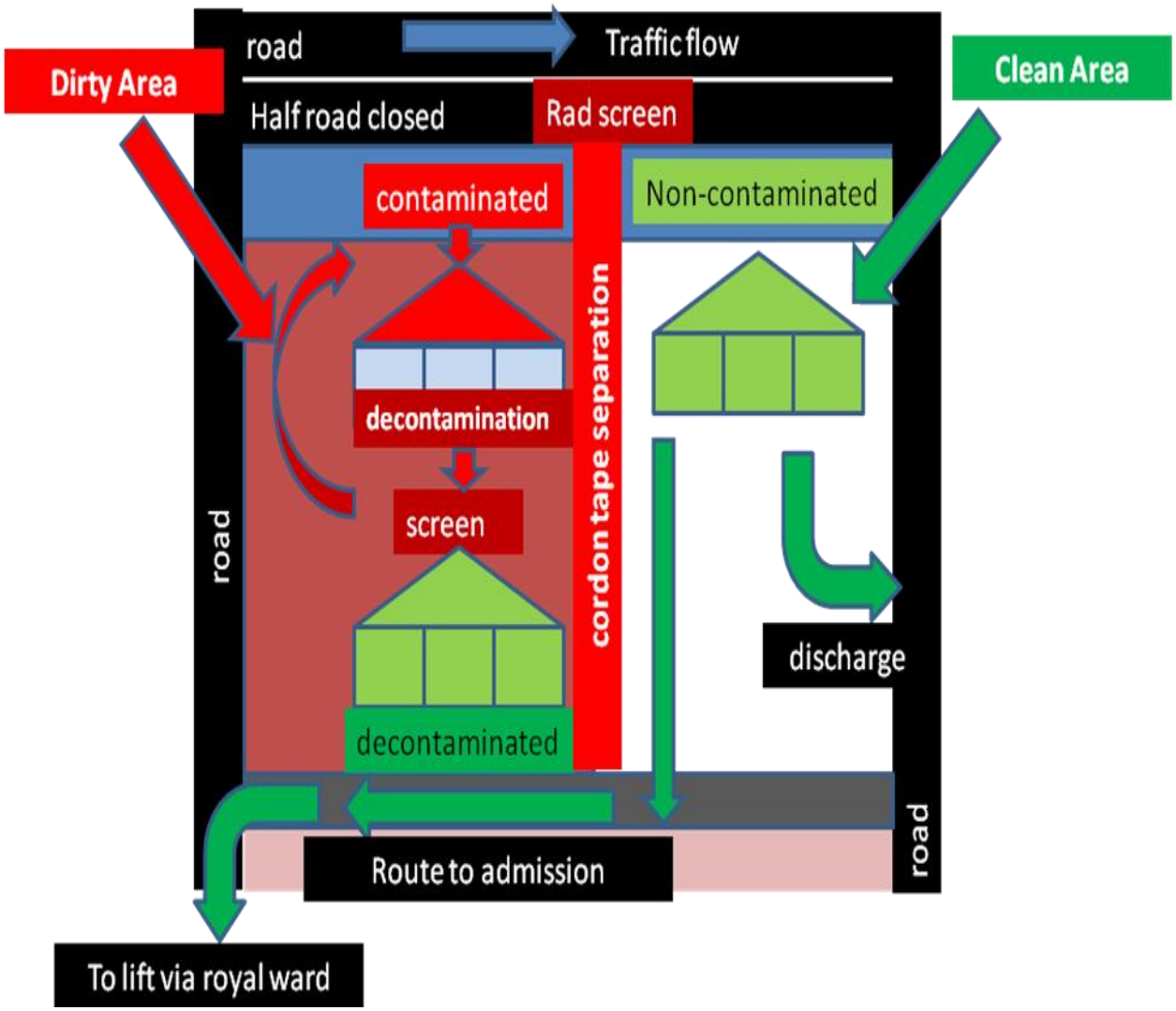


Figure 3.9: Outline of Emergency Radiation Treatment Area (ERTA) for Mass Casualty at the Emergency Department of Hospital Kuala Lumpur

***Location: at ambulance Bay behind Emergency Department**

3.8.8 MANAGEMENT OF PATIENTS' BELONGINGS

Care must be taken for patients' belongings. All valuables such as wallets and hand phones should be put in a plastic sealed bag and labelled. The belongings too should be screened before being returned to patients to ensure no contamination

Personnel could be assigned the role of taking care of patients' belongings while they undergo decontamination process.

4.0 ON-SITE MANAGEMENT OF VICTIMS

4.1 MEDICAL EMERGENCY RESPONSE TEAM (MERT) FROM HKL

The Malaysian Emergency Co-ordination Centre **(MECC)** at HKL may dispatch the usual nearest ambulance to the site upon receipt of emergency call. This ambulance team will assess situation while the HKL assembles the **Medical Emergency Response Team (MERT)** from **HKL.** The **MERT** team comprises of:

1. Emergency Physician or Medical Officer (leader)
2. Staff Nurse
3. Assistant Medical Officer
4. Health Attendant
5. Physicist (Radiation Protection Supervisor –RPS)
6. Driver

- All team members must wear standard PPEs (cap, goggles, mask, gown, apron and shoes cover)
- Ambulance team arriving at the accident site should immediately report to the individual in charge of the facility's radiation protection.
- If the accident is large enough, a command post may be set up. In this situation, the responding team should report to the On-Scene Commander at the command post. According to the Prime Minister's Directive 20 of National Security Council, the police will play the role of On-Scene Commander whilst the Fire & Rescue Services will play the role of Forward-Field Commander. In radiation situation, the HAZMAT unit from the Fire & Rescue Services will play the role of rescue and decontamination of patients.
- The most senior and most experienced member of the team should play the role of Medical Commander. The ambulance team should leave one person at the command post to play the role of Medical Liaison Officer and proceed to set up Medical Base Station.

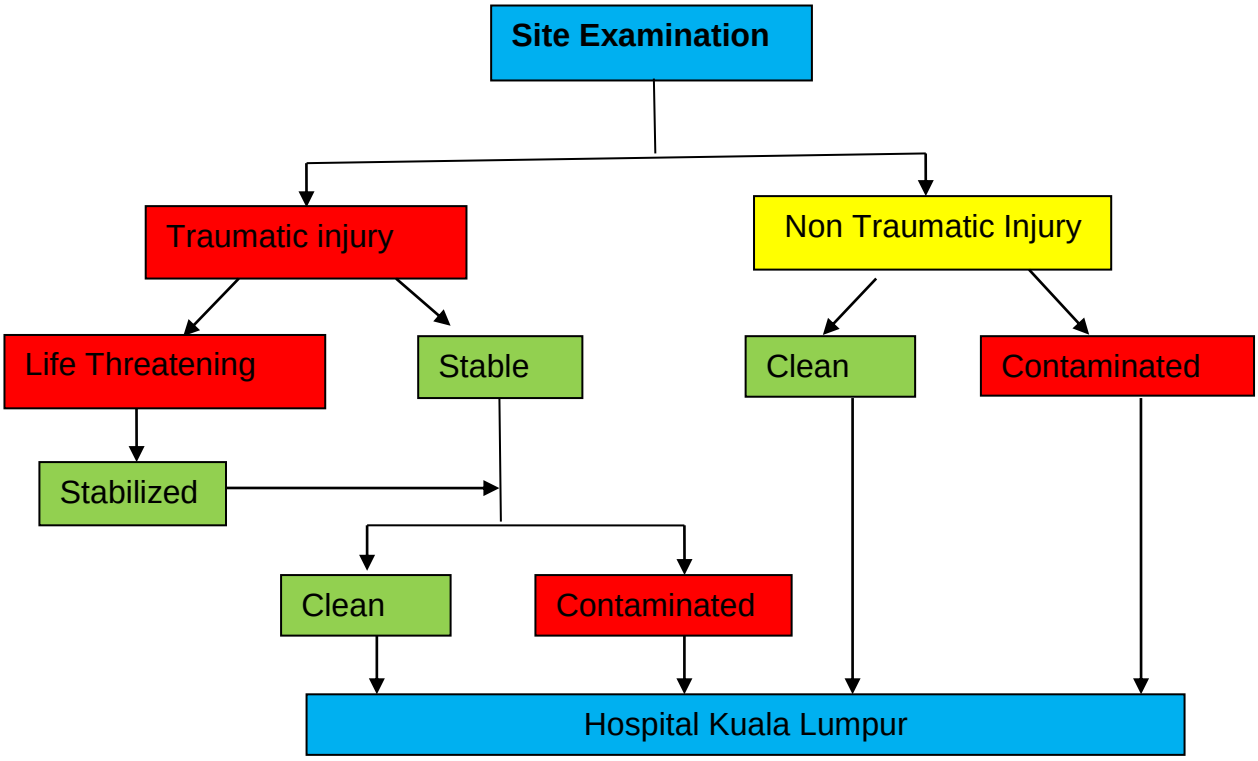
- The **AELB** will assess and declare the status of the site for the **MERT** to operate. Radiation screening should be initiated at the Casualty Collecting Area. This can be done by the RPS if has not been performed by HAZMAT or AELB. Medical triaging should be initiated after radiation screening. Pure 'exposure' patients can be treated like any patients but 'contaminated' patients need to be decontaminated.
- Nevertheless, in the event of emergency need, 'contaminated' patients may still need to be given emergency medical treatment first even without decontamination. From past global experiences, the doses affecting medical personnel in this event is still very low and it is sufficient for medical personnel to respond wearing the standard PPE used in any barrier- nursing situations.
- Ambulance personnel should be notified which entrance has been designated for receipt of radiological casualties for transport to the emergency room.

4.2 SUMMARY OF ACTIONS TO BE TAKEN BY THE MERT AT THE ACCIDENT SITE

The following are the actions need to be taken by **MERT:**

a) Obtain information and order from **On-site Commander**. The medical team will remain in the "Yellow Zone". All person suspected / exposed will be sent to the Hospital Kuala Lumpur. On-Site Commander will identify these individuals.

b) **Radiological Triage (**This is to be done together with **AELB** if multiple casualties are involved; temporary work area for first aid treatment; medical physical procedures and triage examinations need to be established). **(please refer to *Appendix 7).***



*Unstable patients must be given medical management despite not being decontaminated. Decontamination may be performed later

Figure 4.1: Management of Patient with Accidental Irradiation

Triage following known or suspected radiation accident includes both medical and radiological considerations. Medical triage should be based for medical management of persons involved in an accident with radioactive materials and on considerations dependent on the severity of injuries.

A slow, thorough examination of the entire body survey should permit radiological triage resulting in **two groups**:

a. Individuals with **no detectable external contamination (exposure only)**

b. Individuals with radioactive **contamination of skin, hair or wounds (contaminated)**

4.2.1 CONTAMINATED PATIENTS

Contamination of a patient can be determined in the field, on the way to a medical facility, or at the hospital. Patient who has received large absorbed doses may have symptoms such as nausea, vomiting fatigue and weakness. Survey should include techniques and instrumentation for detecting **alpha, beta** and **gamma** radiations or any combination thereof.

4.2.1.1 External Contamination

Individuals found to be **externally contamination** should have their clothing removed, shower, dry and then be resurveyed. Once decontaminated to the extent possible, **clean clothing should be made available**. Any wounds must be considered contaminated unless proven otherwise. Some of them may result in incorporation of radioactive material in the body.

4.2.1.2 Internal Contamination

Internal contamination is usually more difficult to assess under triage conditions. Following high-level internal contamination with radionuclide emitting high-energy beta particles or photons, the assay of urine samples using hand held survey instruments might be helpful. At the rescue site, wear glove and protection clothing at all time. (*See Appendix 8 for using Survey meter*).

4.3 ACCIDENT SITE MANAGEMENT FOR MASS CASUALTY ACCIDENT

Mass casualty accidents are managed according to Directive 20 of National Security Council. This directive states that during a mass casualty accident, the police will play the role of the On-Scene Commander, the Fire and Rescue will be the Forward Field Commander whilst Medical team from Ministry of Health will be the Medical Commander.

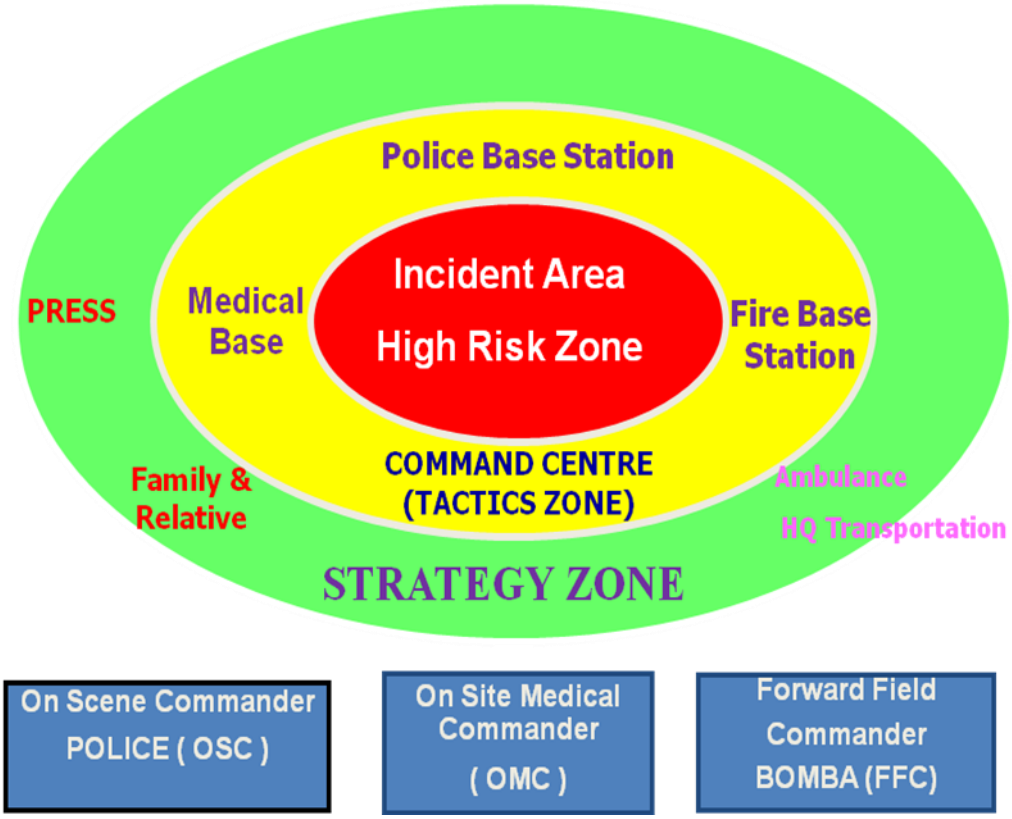


Figure 4.2: Disaster Zoning: Red, Yellow and Green Zones

The area surrounding the accident site is divided to three zones (as shown in diagram above):

1. **Red zone**
   a. From the point of accident outwards
   b. Is a danger zone
   c. Is controlled by the Fire and Rescue Department personnel
   d. The distance depends on the danger posed by the hazard (if normal accident about 50 meters radius from the centre but in radiation accident, the radius can run into hundreds of kilometers)

2. **Yellow Zone**
   a. This is the relatively safe zone, from the outer periphery of the red zone to the inner periphery of the green zone
   b. Usually about within 100 meters from outer periphery of red zone

c. Command Posts, Medical Base Stations and Fire Base Stations are stationed here

3. Green Zone

a. This is the safe zone

b. Media, relatives and other non-essential people will be stationed here

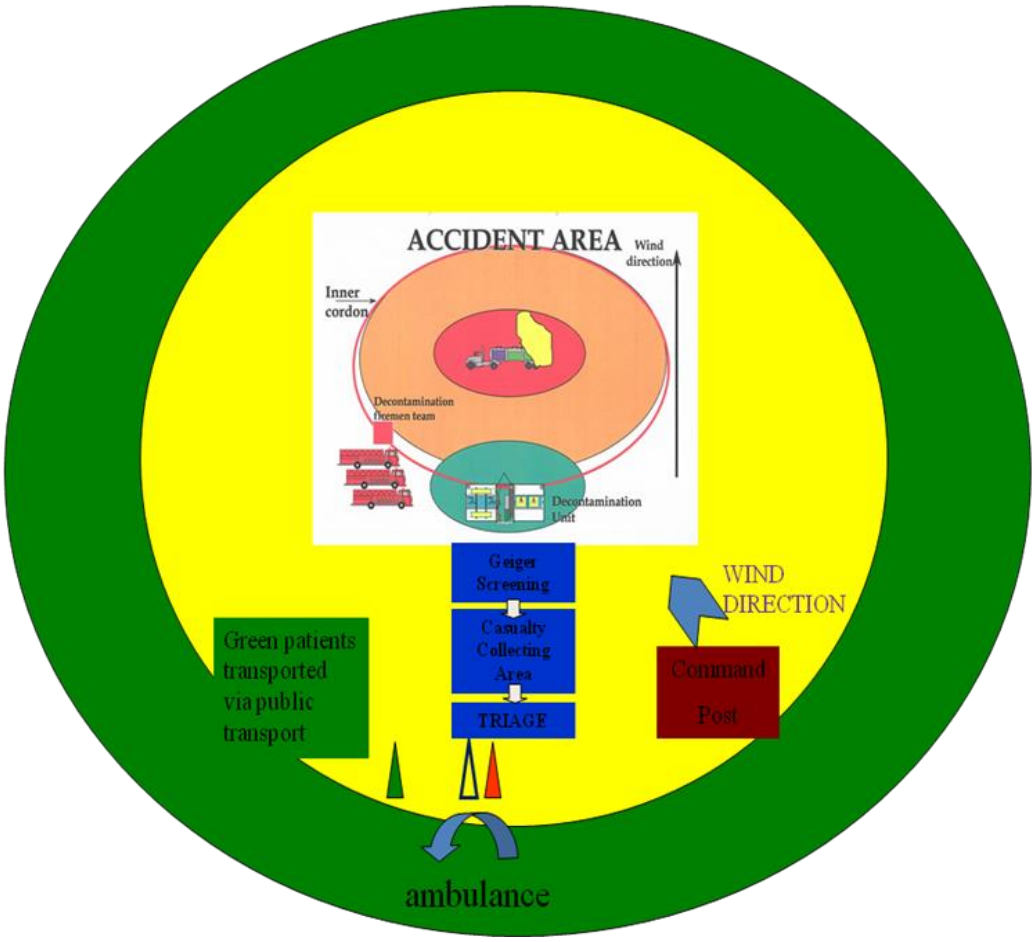
The Command Post is the place where all agencies report to a liaison officer is left to assist the On-Scene Commander.

4.3.1 THE ROLE OF MEDICAL COMMANDER

- This role is taken up by the most senior and most experienced in the medical team that has arrived. The role can be 'passed over' to another member who arrives later if he is more senior and experienced. All agencies that come to the accident site to provide medical care will work under the command of the Medical Commander.
- Report duty to the On-Site Commander at the Command Post
- Leave a liaison officer at the Command Post
- Establish Medical Base Station

- Start triaging process :
  - Walking well patients are automatically triaged green and transported with public transport (bus or lorry)
  - Patients who cannot walk are triaged either red (life-threatening) or yellow (semi-critical). Dead patients are triaged as white.
  - Category red patients are transported first with ambulance to the hospital followed by category yellow
- Medical management is provided to patients while waiting for ambulance

- Under the Medical command, medical teams from various agencies or other hospitals will work together to provide medical care



***For radiation accident involving mass casualty, a modification is made to this system**

Figure 4.3: Radiation Disaster Zoning

4.3.2 MASS CASUALTY ACCIDENT MANAGEMENT INVOLVING RADIATION

In Radiation Accident Involving Mass Casualty, patients will be decontaminated first by the **HAZMAT** team from Fire and Rescue before being delivered to the casualty collecting area (cold zone). Patients are screened for radiation after decontamination before being passed to medical attention.

- After screening, a sticker will be put on patient (example: blue for contaminated, orange for exposure). This will help medical providers to know that they had been screened and the status would be clear. The sticker could be on triage card which will also determine which triage category is on (red, yellow, green or white).

- Non contaminated patients can be managed in same manner like any patients. Contaminated patients must be managed with protection (either via distance, time or shield) and Physicist will advise this. Affected patients will be sent to hospital.

4.3.3 WHEN THE NUMBER OF PATIENTS IS OVERWHELMING

If the number of patients is overwhelming (in hundreds), non-symptomatic and non-contaminated patients may be allowed to go home but with a planned follow-up at a designated place (either a hospital or clinic). Nevertheless patients will have to be advised to come straight to the hospital should they develop any symptoms (nausea, vomiting, diarrhea etc.).

Situation of Atomic Plume (e.g.: Exploded Nuclear Reactor, Atomic Bomb or Exploded Nuclear-Powered Ships)

- A survey centre could be set up. For example, a designated school, stadium or hall could be used as screening centre.

- Those who escape from atomic plume could be advised to wash their face, hair and hands (as usually workers are covered by their clothes). A facility to self-wash themselves could be established at the designated place.

- A crowd control mechanism with loud speakers, hailers etc. could be established and the police or army can be called for this.

- A team of health physicists could be sent to this area to screen victims.
- Post screening, patients would be divided into two groups :
    - Exposure (tagged or given ‘orange’ sticker)
    - Contaminated (tagged or given ‘blue’ sticker)
- Decontamination should be performed further for ‘contaminated’ patients
- Iodine tablets could be distributed as prophylaxis to prevent thyroid cancer.

4.3.5 PATIENTS WITH LIFE-THREATENING CONDITION IN RADIATION ACCIDENT

Patients with life-threatening condition needing urgent medical care may be passed to the medical team without being decontaminated.

In this situation, immediate medical care given and patient will have to be transported immediately to the hospital via ambulance. For this, the Physicist from the ambulance team may do the radiation screening en-route and provide advice to the health provider.

In this situation, decontamination will be done in the hospital. The emergency department call center is to be informed before patient is sent to the hospital so that preparation could be made.

At all time when handling radiation patient, personal protective equipment should be applied (head cover, goggle or eye shield, gown and apron.)

4.3.6 PERMITTED RADIATION DOSE FOR MEDICAL STAFF ATTENDING PATIENTS IN RADIATION ACCIDENT

Based on *Basic Safety Radiation Safety and Protection Regulation (2010)* in Malaysia, for radiation workers, the limit is set lower at 20mSv/year. For layperson (public) or pregnant radiation workers, the limit is set at 1mSv/year.

Usual precaution should be observed; do not aggravate injury during the procedure

5.0 FACILITY PREPARATION & PATIENT HANDLING AT THE HOSPITAL

5.1 ACTIONS AND FACILITY PREPARATION

5.1.1 PROCEDURE AT EMERGENCY DEPARTMENT

On notification, the **Emergency Physician** on duty would:

1. Obtain **on-site information**, including:
    a. Type of radiation accident: irradiation, contamination and/or both
    b. Number of uncontaminated victims and their condition
    c. Number of contaminated victims and their condition
    d. Type of radioactive isotope(s) - if possible, get sample from site.
2. Pass all relevant information to the Head of Emergency Department
3. Decide on sending field medical team to the accident site
4. Notify the matron, RPO, Security Officer, PRO HKL, and other members of the ,Radiation Emergency Team Committee (RETCOM) where necessary
5. Take charge of victim(s) or delegate duty to another person
6. Decide on opening decontamination/emergency treatment area.
7. Decide on opening bigger screening/decontamination area at the back portion of the Emergency Department (the ambulance bay) if the number of casualties is large.
8.

The **Head of Department of Emergency**'s actions are as stated below:

i) Decide whether to implement radiation accident plan

ii) Advise the hospital director accordingly

iii) The hospital director must decide whether or not to activate the hospital disaster plan (by declaring yellow or red alert)

iv) Give instructions to Emergency Physicians on duty and all staff in the Emergency Department to facilitate the handling of radiation victims.

v) In mass casualty accidents will play the role of Clinical coordinator

5.2 CLASSIFICATION OF PATIENT RADIATION INJURIES

a) External exposure only (irradiation only): Treat in normal emergency area. There is no need to use REA (radiation emergency area) and there is no radiation protection rule needed. Follow the protocol for exposed patient for dosimetry, treatment and long term follow-up.

b) Contaminated patient with or without external injuries: requires full activation of Hospital Radiation Disaster Plan and use of REA for decontamination. Procedure for decontamination should be applied.

c) Patient with unknown contamination status (commonest situation in emergency): should be treated as for contaminated patient.

5.3 FACILITY PREPARATION

5.3.1 DECONTAMINATION ROOM PREPARATION

Emergency Department Sister on duty shall work with AMO Supervisor on duty to prepare the decontamination room as the emergency radiation treatment area (ERTA). Emergency Physician on duty as well as the RPO shall supervise in preparation of the ERTA:

- Cover floor with plastic sheet or brown paper or absorbent paper and secure to floor with tape
- Place strip of tape on floor at entrance to **ERTA** so as to delineate contaminated side from non-contaminated side.
- Remove all non-essential equipment from the room
- Cover all light switches and handles on cabinets and doors with tape.
- Provide a suitable decontamination tray or stretcher for the patient.
- Provide several large plastic or metal containers with Bio-Hazard plastic bags to receive discarded contamination items, such as clothing, gauze and disposable supplies.
- Survey and record background radiation level in **ERTA** room. (Health Physicist/RPS assigned this role by the RPO)
- For supplies needed at decontamination room **(please refer Appendix *10)***
- In situation of mass casualty, a larger ERTA shall be prepared at the ambulance bay as stated in the earlier chapter.

5.3.2 DECONTAMINATION TEAM PREPARATION

Decontamination team is assembled from the Emergency Department as below:

Table 5.1: Decontamination Team Preparation

PERSONNEL	FROM
Medical Officer	Room 3
Medical Assistant	Triage
Attendant	PRO
Staff Nurse	Triage
RPS/RPO	From RPS pool

Personnel protective equipment:

i) Wear full surgical gear

- Change into O.T clothes
- Wear boots not O.T slippers
- must wear gloves, cap, eye protection and mask
- Tape glove to gown
- Use double gloves

ii) Use personal dosimeter

iii) RPO/RPS to take reading at intervals during decontamination procedure

vi) **Do Not Cross From Contamination to Non Contamination Side Without Removing All Outer Clothing.**

vii) Supplies needed for decontamination team
(Please refer *Appendix 11)*

viii) A CCTV should ideally be installed for monitoring of process from outside.

5.4 DECONTAMINATION TEAM DUTIES

Table 5.2: Decontamination Team Duties

NO	POSITION	RESPONSIBILITIES
1.	Doctor (from Green Zone Room 3)	Takes charge of medical needs of patient
		Directs decontamination procedure
2.	In-charge Nurse (Triage)	Designates persons who will remain outside **ERTA** and obtain supplies for medical and decontamination teams
		Assists doctor
		Responsible for collection of all specimens and swabs of contaminated areas
		Monitors and records vital signs
3	Medical Assistant	Assists doctor for decontamination or clinical procedures

4	Medical Attendant	Assists medical team and helps with decontamination and moving contaminated clothes etc. into appropriate storage
3.	Radiation Protection Officer (RPO) or Radiation Protection Supervisor (RPS)	Designates person who will remain at **ERTA** entrance to monitor all personnel, equipment and samples leaving **ERTA**
		Monitors patient, decontamination team and other involved persons for radioactivity during treatment and care of patient
4.	Circulating nurse (from resuscitation)	Assists as needed
		Labels all specimens
		Picks up and passes on needed supplies that are delivered to the **ERTA** from the outside
		Records data on areas and levels of contamination as measured by RPO/RPS

5.5 INITIAL EVALUATION

5.5.1 VICTIM'S ARRIVAL ON AMBULANCE AND EVALUATION

- Ambulance is parked at a separate entrance from usual entrance, if possible, usually far away from normal traffic flow of the hospital (e.g. use back entrance)
- Stretcher cover with paper/plastic is brought to the ambulance to receive victim who may be contaminated.
- If patient is stable, RPO or RPS may perform radiological screening

5.5.2 TRIAGE & EARLY TREATMENT

- Preferably a preliminary examination by physician and RPO/RPS is done, while the patient is still in or near the ambulance. Attention should be given to airway, breathing and state of circulation. Determine the extent of injuries and degree of contamination.
- Primary Triage followed by Secondary Triage (BP, HR, RR, T) is performed. If critical, even if contaminated patient goes directly to the emergency department or **ERTA** without waiting for a radiation survey; do not bother to remove contaminated clothing at this stage.
- Administer drugs, fluids and medical or surgical procedures as needed for stabilization of patient.
- If not critical and contaminated, the patient is removed from vehicle and placed on stretcher, clothing is removed and left at the ambulance, the patient is then covered with a cloth or sheet and then taken to decontamination room or **ERTA**. **Do not wrap the patient in plastic sheet.**
- If not critical and non-contaminated, patient goes, still dressed to regular trauma section of emergency department.
- Obtain all other requisite laboratory samples, electrocardiograms and radiographers according to patient's medical status.
- Take swab samples of ear canals, nares and mouth as soon as possible and before washing or showering.
- Blood (for Full Blood Count with differentials, type and cross-match, Renal Profile, Liver Function Test, Thyroid Function Test and chromosomal analysis), urine (for routine urinalysis) as well as other excreta (for radio assay) *(Appendix 12)*
- Place samples in separate lead container; label with patient's name and ID, samples site and time.

- Store containers in **lead receptacle** or at a remote safe place until they can be tested for radioactivity.
- All samples should survey by RPS, those non-radioactive can be labelled non-radioactive and sent to lab in normal manner. Those which are radioactive (e.g. excreta) has to be put in lead receptacle and sent to lab in IMR or AELB.
- RPO/RPS monitors entire patient including back, areas and amount of contamination are recorded on anatomic chart
- Take all samples of all contaminated areas and store in similar manner to the above.

5.5.3 SCREENING OF AMBULANCE PERSONNEL

- Ambulance personnel remain with the ambulance until they and the ambulance are monitored or decontaminated.
- If non-contaminated, both are returned to duty.
- If contaminated, RPO/RPS will give instruction for decontamination of persons and/or vehicle before they are allowed to resume their normal duty.

5.5.4 THE SECURITY/AUXILLIARY POLICE CHIEF IS INSTRUCTED TO:

i) *Clear the traffic from ambulance entrance to* decontamination room or Emergency Radiation Treatment Area (ERTA) of unnecessary patient and personnel.

ii) *Prepare pathway from ambulance to ERTA:*

- cover route from ambulance entrance to decontamination room (ERTA)

- mark off above route with ropes and label it
"RADIOACTIVE" until it has been declared safe by RPO.

- For supplies needed see **(please refer *Appendix 10)***

5.5.5 AMBULANCE DECONTAMINATION

- Ideally a special ambulance equipped with collection system of spills for ferrying radiation patient is needed. Otherwise, plastic sheets may be used to cover the ambulance floor and seats where patient will be ferried.
- If contamination is detected from screening with Geiger Muller probe, ambulances used for carrying contaminated patients must be decontaminated before use for another patient.
- After finished transporting patient, the ambulance is taken to a secluded place (near ambulance bay) and decontaminated :
    - Plastic sheet cover removed
    - Ambulance survey by RPO/RPS
    - If contaminated (as detected by survey), any substance removed or
    - Affected site is cleaned with chlorox/water and collected in plastic lined container.
    - The waste should be collected and passed to AELB for advice on processing
- The cleaning of ambulance is done by the driver and attendant wearing PPE.
- Victims of unknown status either contaminated or not should be assumed contaminated until confirmed by screening.

5.5.6 WHAT TO DO IF THE PATIENT ARRIVES UNANNOUNCED

- Continue attending to the patient's medical needs
- Secure the entire area where victims and attending staff have been
- Do not allow anyone or anything to leave area until cleared by RPO
- Establish control line
- Complete assessment of patient radiological status
- Personnel should remove contaminated clothing before exiting the area; they should be surveyed, showered, dressed in clean clothing and be resurveyed before leaving area.
- Further management depends on the status of exposure of the patient and will follow standard protocols.

5.5.7 PATIENT DECONTAMINATION

Decontamination process is as described in table below:

Table 5.3: Patient Decontamination

NO	INJURY TYPE	TREATMENT
1.	Open wound (s)	Wash wound(s) with normal saline for three minutes. All irrigated fluid from any part of the body should be collected in a special container provided Monitor for radioactivity-repeat saline wash and resurvey until her background level of radiation or steady state is reached. If contamination is persistent, wash wound(s) with 3% hydrogen peroxide solution or other appropriate agent.
2.	Eye	Rinse with stream of water, nose-to-temple direction away from medical cantus. Monitor and repeat rinsing as needed.
3.	Ear canal	Swab first, then rinse gently with small amount of water; apply suction frequently. Monitor and repeat rinse as needed. If possible, turn head to side or down
4.	Nares or mouth	• Rinse gently, with small amount of water; suction frequently. Urge patient to avoid swallowing. • If contaminant is known or suspected to have been ingested, insert nasogastric tube into stomach; suction and monitor contents. If gastric contents indicate radioactivity: • Lavage stomach with small amounts of normal saline until washings are clear of contaminant. • Begin decorporation procedure (See Appendices 13,14,15)
5.	Intact skin	• Using soap and tepid water, gently scrub with soft brush for a few minutes- do not redden or irritate

		skin. An ambulatory patient with widespread contamination can be showered. • Monitor and repeat washing as needed. • If contamination persists: • Use a mild, abrasive soap or a 1:1 mixture of liquid detergent and cornmeal; or • Use Clorox (full strength for small areas, diluted for large areas and around face or wounds).
6.	Hair	• Wash with mild shampoo for three minutes and rinse. • Monitor and repeat washing as needed. • If contamination persists, clip off hair but do not shave.

*__NOTE__: During decontamination the patient's vital status should be checked regularly. Following decontamination the attending physician should perform a more complete physical examination and obtain a complete medical history. **(please refer Appendix 16)**

5.6 POST EMERGENCY PROCEDURE: PATIENT TRANSFER

5.6.1 PATIENTS EXIT FROM DECONTAMINATION ROOM

Exit from decontamination room:

- Dry patient
- RPO/RPS surveys patient's entire body for radioactivity
- If RPO/RPS is satisfied with the results, a clean floor covering is placed from **ERTA** exit to patient and if needed, from exit to a clean stretcher outside decontamination room.

- Clean stretcher or wheelchair is brought in if patient is not ambulatory.
- Transfer patient to clean stretcher or wheelchair, attendants should not be those who took part in the decontamination procedure.
- RPO/RPS survey stretcher and wheel of the trolley or wheelchair as it is about to leave decontamination room.

5.6.2 STAFFS EXIT FROM EMERGENCY RADIATION TREATMENT AREA (ERTA)

Exit of decontamination team:

- Team members remove their protective clothing in the following sequence at the " clean line " and place it in a plastic container marked **"contaminated".**
- Outer gloves are removed first; turn them inside out as they are pulled off
- Dosimeters are given to RPO.
- Remove apron
- Remove tape at trouser cuffs and sleeve.
- Remove surgical gown; turn inside out and avoid shaking
- Remove surgical shirt.
- Removed head cover
- Pull surgical trouser off over the shoe cover
- Remove mask

- Remove shoe cover from one foot; if shoe when surveyed by RPO is clean, step over “clean line”, remove other shoe. Cover and the other shoe are monitored. If either shoe is contaminated, remove.
- Face the treatment room, then remove inner gloves and discard them into the labeled waste bag.
- Survey feet and hands for a final time; if free of radioactive contamination, leave the area.

6.0 SPECIAL MEASURES AND SITUATION

6.1 MEASURES FOR DEALING WITH WASTE

- Contaminated waste should be dealt with in accordance to the generally accepted regulations for handling radioactive waste.
- Any suspected waste should be considered as a contaminant, as long as no proof to the contrary exists. When the radioactive contaminant has a short half-life, it should be mandatory to keep it for the necessary length of time in a locked, ventilated room with a warning on the door. A place could be identified at the Oncology & Radiotherapy Department while waiting for decay to complete in certain source.
- With certain highly contaminated materials it is better to dispose of them as soon as authorized to do so, than to undertake a long, difficult, costly and incomplete decontamination process.
- Patients found to be contaminated with radioactive substance will be admitted to Ward 28 as isolation ward. Barrier nursing (similar like handling any infectious disease patients will be utilized)
- Patients exposed to radiation (but not contaminated) can be managed in normal medical wards.

6.2 MEASURES TO BE TAKEN IN THE EVENT OF A SURGICAL PROCEDURE

The special precautions intended for protecting the hospital facilities and its staff are as follows:

6.2.1 PROTECTION OF OPERATION THEATRE & STAFF

- Protect the operating theatre, covering the table, floor, etc. with disposable plastic sheets.
- Operation Theatre Staff should don Personal Protective Equipment. Surgical gown with head cover, goggles, apron & shoe cover should be

acceptable. Personal protective equipment (PPE) Level 4 (gown, gloves, mask and shield, goggles, caps and shoe covers) should be worn by all staff. The purpose of protective clothing is to keep bare skin and personal clothing free of contaminants.

- All open seams and cuffs should be taped using masking or adhesive tape. Fold-over tabs at the end of each taped area will aid removal.
- Two pairs of surgical gloves should be worn. The first pair of gloves should be under the arm cuff and secured by tape. The second pair of gloves should be easily removable and replaced if they become contaminated.
- This protective clothing is effective in stopping alpha and some Beta particles but **not gamma rays.** Nevertheless, lead aprons, such as those used in the x-ray department, are not recommended since they give a false sense of security as they will not stop most gamma rays.

6.2.2 SURVEYING RADIATION

- Survey instruments should be checked and ready for use before the patient arrives. Background radiation levels should be documented.
- Physicist (RPO/RPS) must provide information regarding maximum tolerable duration of exposure for each staff for that particular contaminated patient based on the initial screening.
- Duration of contact and surgery should be made as brief as possible if the contamination level is high.
- Personal dosimeter should be worn by all operating theatre staff coming in close contact with the contaminated patient. It should be attached to the outside of the surgical gown at the neck where it can be easily removed and read.

- Detection instruments (survey meter) appropriate to the nature of the contaminant, for monitoring the operative fields, surgical and anesthesia equipment are required.

- Respiratory and digestive probes should be checked for contamination after use. All suction materials to be disposed appropriately.

6.2.3 GENERAL MEASURES

- Use disposable anesthesia and surgical equipments wherever possible. All contaminated clothing should be considered as waste.
- All staff exiting from the operating theatre must be screened for contamination.
- Only relevant staff to be allowed into the operating theatre and movement should be restricted. Proper documentation of in-out movement should be done.
- All biological waste and specimens must be screened for contamination before further processing.
- Shielded container should be used for transfer of all contaminated clinical waste and specimens.
- Operating theatre should be checked for contamination after the surgery. Decontamination procedures should be adhered to ifound to be contaminated.
- Operating theatre should not be used for other cases until confirmed to be free from contamination.
- Do not eat, drink, smoke, rub eyes, or apply makeup within the operating theatre.

6.3 MEASURES TO BE TAKEN IN THE EVENT OF DEATH OF A CONTAMINATED PERSON

- If the deceased is known or suspected to be contaminated, personnel engaged in handling of the body should be issued personal protective equipment (PPE) and a personal pocket dosimeter.
- All persons coming into contact with the deceased should be aware that other, more acutely hazardous agents, may be present such as non-

radiological contaminant hazards (e.g., chemical agents) and may pose more significant risks to health and safety of persons handling the body which may need higher levels of PPE.

- Bodies should be surveyed in the field using a radiation survey meter and probe sweeping **1 inch** away from the body surface.

6.3.1 DECEASED WITHOUT MEASURABLE LEVEL OF EXTERNAL CONTAMINATION

- Confirm absence of contamination by conducting complete radiation survey of the body.
- Transport body directly to the mortuary following complete radiation survey

6.3.2 DECEASED WITH MEASURABLE LEVEL OF CONTAMINATION

- *<100 millirem/hour (< 1 mSv/h) : may be processed in field mortuary*
  - Remove and safely store radioactive shrapnel as soon as possible.
  - Conduct forensic examination and victim identification
  - Decontaminate the deceased prior to release of body
- *>100 millirem/hour (> 1 mSv/h): move to a refrigeration unit*
  - Storage of bodies reading >100 mrem/hr in refrigerator at safe distance will help to ensure safety of mortuary staff
  - Refrigerator should be at least 30 feet (about 10 meters) away from work area
  - Radiation Protection Officer (RPO) or health physicist will help determine how long to store the body based on rate of decay of fission products
  - Storing the body for several days at -20^0C or -30^0C helps to overcome the problem where short-lived emitters are involved. It is in fact rare for the contamination level to be such as to pose

problems for burial. Bodies must be labeled with dose rate, distance of probe, date & time

- It is necessary to consult the regulations if the body is to undergo special preparation, to be cremated, or to be embalmed. This practice should be avoided unless it simply involves injecting a fixing substance. Nevertheless, the persons performing the embalming should take all the usual precautions for handling radioactive contaminants.

- Similarly, procedure like '*mandi mayat & kapan'* practiced for Muslims can only be allowed with the instruction and plan by RPO/RPS after the dose rate is determined. The distance, time and shield could be determined so that the procedure could be performed within limited time and safe.

- The same precautions should be taken during the autopsy, which should be made as brief as possible if the contamination level is high. In the latter case a radiation protection officer should assist the pathologist.

6.4 FIELD OPERATION PROTOCOL FOR RADIATION ACCIDENT DURING TRANSPORTATION OF RADIOACTIVE MATERIAL

Occasionally the medical team from Hospital Kuala Lumpur is summoned for assistance when an accident occurs during transportation of radioactive material. The following is the field protocol that should be used by the team while rendering assistance at the site of accident.

- Put on protective clothing and use personal dosimeter and survey meter if immediately available

- Approach the site with caution; look for evidence of hazardous materials

- If radiation hazard is suspected, position personnel, vehicles and command post at a safe distance (200 – 300 feet/50-100 meters) upwind of the site

- Notify proper authorities (HAZMAT team of Fire & Rescue Department) and hospital.

- If control lines are not yet established, assist the AELB staff in establishing control line. The control line preferably consist of 3 areas: contaminated area (Hot Zone), non-contaminated area (Cold Zone) and an area outside the outer control line.

- Determine the presence of injured victims

- Assess and treat life-threatening injuries immediately. **Do not delay** advanced life support just because victim cannot be moved or just because the personnel wants to assess contamination status. Perform routine emergency care during extrication procedures.

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

- Expose wounds and cover them with sterile dressing.

- Monitor victims at the control line for possible contamination only after they are medically stable. Radiation levels above background indicate the presence of contamination. Remove the contaminated accident victims clothing.

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

  **The ambulance should ideally be covered with plastic sheet/brown paper so that in case a radioactive material spills/drops on the floor, it could easily be removed/cleaned later.*

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

- Before leaving the controlled area, rescuers should remove their protective gear at the control line. If possible, personnel who have not entered the controlled area should transport the victim. Ambulance personnel attending to victims should wear gloves.
- Transport the victim to the hospital emergency department.
- Follow the hospital's radiation protocol upon arrival
- The ambulance and crew should not return to regular service until the crew, vehicle and equipment have undergone monitoring and necessary decontamination by the RPO/RPS
- Personnel should not eat, drink, smoke etc. at the accident site, in the ambulance or at the hospital until they have been released by the RPO/RPS

6.5 SITUATION OF RADIATION CONTAMINATION DETECTED AT THE AIRPORT

- Our major airports in Malaysia are equipped with gamma ray detector
- In situation whereby a person is detected to be emitting radioactive ray, he is to be isolated at the isolation room. Personnel at airport should don PPE before handling patient. Call Atomic Energy Licensing Board (AELB) at 1800-88-7999 (AELB Emergency Hotline N umber). The AELB may send a physicist to conduct radiation survey on patient. Meanwhile, AELB personnel may also provide advice as to what to do with the patient. The AELB too may assist in performing decontamination for the patient.
- Usually the initial measure is to remove clothes and wear a garment (90% of contaminant is removed simply by removing clothes and the other 10% removed with water and soap).
- If the person is sick and not stable, he may be stabilized by health personnel if available at the airport or transported to nearest hospital.

The hospital should be alerted to receive patient and make necessary preparations. Be aware that, IAEA recommends attending unstable patients even without decontamination. (Responders can still take some amount of radiation exposure safely).

7.0 MANAGEMENT & TREATMENT OF PATIENTS

7.1 INTRODUCTION

- The **irradiated and non-contaminated** accident victim is only exposed to an external or remote source of ionizing radiation.
- The victim is **not radioactive** and does not emit ionizing radiation. The victim can be treated in the common emergency room. The externally irradiated victim is a relatively an uncomplicated case since the likelihood of immediate severe morbidity is usually minimal. Thus any associated traumatic injury or accompanying illness should be treated first.
- The initial signs and symptoms are not devastating and require little active care during the first **48 hours**. The clinical course of radiation injury unfolds over a period of time, usually days or weeks and is usually very predictable.
- The severity of the clinical manifestation will depend on a number of factors such as:

1. Time during which the exposure took place.
2. Total accumulated dose
3. Nature of radiation

- The clinical manifestations of external ionizing radiation injury, which can be classified as:

1. Acute radiation syndrome,
2. Acute localized radiation injury
3. Internal Contamination

Basically, there are five types of injuries or combination of injuries associated with radiation and radioactive contamination as tabulated below:

Table 7.1: Types of Injuries or Combination of Injuries Associated With Radiation and Radioactive Contamination

CATEGORY	DESCRIPTION AND TREATMENT
Category A	**Simple trauma with no irradiation and no radioactive contamination**. Does not constitute radiation hazard to both attendants and patients. Should be treated like any other patient with physical trauma.
Category B	**Patient exposed to external radiation only. No radioactive contamination.** Exposure can be to a part of the body or whole body. Does not constitute a risk to attendants or public. Irradiation can occur following an exposure to a radioactive source or as an accidental exposure to X-rays in radiology and radiotherapy departments. Treatment is in the form of symptomatic and supportive measures. Exposure to more than 10 rem (100 mSv) requires observation and blood examination to identify the dose received. Exposure to high doses, i.e. more than 200 Rad (2 Gy) to the whole body produce Acute Radiation Syndrome (ARS). Symptomatic treatment is needed. These include symptomatic pain relief maintenance of electrolyte balance, prevention and treatment of infection, administration of growth factors and/or bone marrow transplant.
Category C	**Patients with internal contamination only (those patients who inhaled/swallowed radioactive material).** Urgent measures to prevent incorporation of radioactive substance are required. The inhaled dose is usually not high enough to produce risks to the medical responders. Its effect on the patient will depend on the types and activity of radioactive material. Need careful examination to assess external contaminations. Need specific measures to minimize the effects of internal contamination.

Category D	**Patients with external contamination of the skin and clothing.** This constitutes a potential risk to both patients and medical responders. Hence adequate protective measures need to be taken and the treatment should be in a specially designated area and away from other patients and public. Immediate protective measures such as removal of clothes and washing of the skin should be done after patient has been stabilized. Items removed need to be collected in radiation hazard labeled plastic bags and sent to radiation laboratory for analysis.
Category E	**Patients with contaminated wound and possible internal contamination.** Like category D there is slight risk to medical responders and the public. Procedures similar to those in category D should be carried out. Care must be taken not to cross contaminate the clean part of the skin from the wounded areas or-vice versa. Any wound excision/debris should also be sent for analysis. Measures to minimize the internal contamination and incorporation of radioactive substances are required.

7.2 ACUTE RADIATION SYNDROME

- Immediate manifestations of radiation injury require a large, single (usually whole body) dose of penetrating radiation that comes from a radioactive source or machine that emits radiation. This may occur in accidents involving nuclear power plants but it can also occur in medical treatment facilities or industrial radiography facilities.

- The symptom complex is an expression of damage or death to many important organs particularly the rapidly dividing cells and stem cells such as in the bone marrow. The signs and symptoms of this syndrome are non-specific and may be indistinguishable from those of other injuries or illnesses.

- Three major organ systems, having different levels of radiation sensitivities respond to high exposures with the following signs and symptoms:

- **Hematopoietic** – from 1 – 8 Gy; signs and symptoms become increasingly severe with dose and pass through four distinct phases:

- A prodromal phase consists of nausea, vomiting and anorexia within a few hours at the higher dose level or after 6 to 12 hours at the lower dose level. These symptoms last 24 to 48 hours, after which time the patient is asymptomatic and may feel well.

- A latent phase may last from few days to as long as 2 to 3 weeks at the lower dose level. The patient is asymptomatic with apparent recovery from radiation exposure but will have a characteristic sequence of changes in the blood elements, the most obvious of which is lymphocyte depression. Stem cells in the bone marrow will replicate in the recovery phase and eventually produce the normal amount of blood elements. Supportive therapy is required until the blood returns to normal.

- **Gastrointestinal** - 8 – 30 Gy, (high dose).

- Distinguishable from the hematopoietic syndrome by the immediate, prompt and profuse onset of nausea, vomiting and diarrhea, followed by a latent period of about 1 week; GI symptoms recur and lead to marked dehydration, vascular effects and death in two weeks.

- The GI mucosa becomes increasingly atrophic, and massive amounts of plasma are lost to the intestine. Despite clinical treatment, death may occur due to massive denuding of the GI tract and accompanying septicemia and dehydration.

- If the patient survives long enough, the haematopoietic system depression occurs and complicates the clinical course. **Cardiovascular/CNS** over 30 Gy, an extremely high dose, to the whole body.

- Always fatal, there is immediate nausea, vomiting, anorexia and prostration, within hours after exposure, the victim, will be listless, drowsy, tremulous, Convulsive and ataxic.
- Death will occur within a matter of hours (24 to 48 hours). The cause of death may be due to changes in the permeability of small blood vessels in the brain.

7.3 LOCAL RADIATION INJURY

- Occurs when a high dose of radiation is delivered to a small area in a short period of time. High dose is delivered to superficial tissues with rapid drop in dose as the radiation penetrates the deeper tissues. As only a small part of the body is involved, normal functions of the body continues after the exposure.
- Systemic symptoms, if it occurs at all are mild in comparison if the local area irradiated is the epigastrium. Generally major organs systems are not involved although sometimes muscle and bone necrosis can occur. The following are the usual manifestations of local injuries:

1. **Epilation Of The Hair**

   Single doses of 4 to 10 Gy result in transient or permanent hair loss. Appears about 17-21 days after exposure and continues for several days thereafter.

2. **Erythema**

   Threshold for this is about 3 - 10 Gy. It appears within hours to days after exposure and remains for a short period of time and disappears. It can appear 2-3 weeks after exposure and last for 20-30 days.

3. **Dry Desquamation**

Occurs in the dose range of 10-15 Gy and appears in about 2-4 weeks after exposure. May last for days or weeks.

4. **Wet Desquamation**

This may occur in the dose range between 20 – 50 Gy and appears in 3 – 4 weeks after the exposure.

5. **Blister**

Can arise in the dose range about 15 - 25 Gy directly from radiation exposure. It appears about 3 weeks after exposure, has a well-defined edges.

6. **Radio necrotic Lesion**

Occurs at doses above 25 Gy. Onset may be between a few weeks to several months.

7. **Other Lesions;**

a. Damage to subcutaneous tissues may result in oedema and sclerosis. The effect of radiation will depend on a number of factors including the types and the energy of the radiation.

7.3.1 TREATMENT OF LOCAL RADIATION INJURIES.

- In most instances a “wait and see” policy is adequate. No intervention is required particularly for epilation, erthema, dry desquamation and intact blisters. Keep the area clean and do not apply any irritating agent. Blind lotion/ aqueous cream can be applied to “dry desquamated” lesions and loose fitting cloth might be helpful.
- Symptomatic treatment: Relief of pain is required if pain is the symptom. Avoid using drugs that cause marrow depression.

- Skin grafting may be necessary for skin lesion. The skin graft provides cover for the area, relieve pain and restores function of the area. The patient need to be seen in collaboration with a plastic surgeon to assess the need for the skin graft.

- Amputation of the gangrenous area may be necessary when all other measures fail and there is no likelihood recovery. Timing of amputation is critical and should be done after adequate assessment of the condition. Again this decision needs to be made in collaboration with an orthopedic surgeon.

7.4 INTERNAL CONTAMINATION

Principles of treatment

- The procedures recommended for the treatment of persons with acute internally deposited radionuclides are intended to reduce the absorbed radiation dose and hence the risk of possible future biological effects.

- These aims can be accomplished by the use of two general processes:

  (i) reduction of absorption and internal deposition and

  (ii) enhanced elimination or excretion of absorbed nuclides.

- Both are more effective when begun at the earliest time after exposure.

- Treatment is most effective if the uptake of contaminants into the systemic circulation is prevented. Administration of diluting and blocking agents is effective in some instances because it may also enhance the elimination rates of the radionuclide or reduce the quantity of radionuclide deposited in tissue. Therapeutic measures that use mobilizing agents or chelating drugs are less effective when the radionuclide has already moved into the tissue cells.

- The most important considerations in treatment are:
    - selection of the proper drug for the particular radionuclide;
    - timely administration after exposure
    - Identification of radiation material
    - Identification of antidote

Table 7.2: Particular Radionuclide

RADIONUCLIDES	ANTIDOTES & DECORPORATION AGENTS	DOSE	ROUTE
Plutonium (Pu) Americium (Am) Curium (Cm) Californium (Cf) Neptunium (Np) Lanthanum (La) Cobalt 60	Calcium DTPA Zinc DTPA	○ **1 gm** in 250 ml normal saline or 5% dextrose in water, IV over 1 hour **OD** for several days to a week in most cases without toxic effects. ○ Inhaled plutonium will need nebuliser DTPA 1 gm over 15-30mins daily and lung lavage	IV nebulise
Radioactive phosphate	Potassium Phosphate	***Adult*** **250-500mg** p.o. **QID**, with full glass of water each time, with meals and at bedtime ***Children*** ➢ 4y, **250mg QID**.	oral

Radioiodine (I-131)	Potassium Iodide Mixture 65mg/15mL (within first 4 hours)	***Adult*** **130mg** p.o **OD**. ASAP, repeat dose daily as long as the contamination lingers in the environment. ***Children*** 4 to18y, 65mg p.o. 1 mth to 3y, 32.5mg p.o. <1 mth, 16.25 mg mixed with a liquid such as low fat milk	Oral
	Propylthiouracil 50mg Tablet	100mg TDS for 8 days	
Strontium Sr-90 Radium	Sodium Alginate	**10 gm** powder in a 30 cc vial, add water and drink	oral
	Calcium gluconate IV	IV 3.0gm in 500ml D5% over 4 hours for 6 consecutive days	IV
Cesium, Thallium, Rubidium	Prussian Blue	**1g** p.o. **TDS** for up to 3/52 or longer as required. Doses up to 10-12 g/day for significantly contaminated adults may be used	oral
Uranium	Sodium Bicarbonate 1.4% IV (available as 8.4% 10ml injection)	**Slow IV infusion 250ml**	IV

7.5 MANAGEMENT AT EMERGENCY DEPARTMENT FOR INTERNAL CONTAMINATION

- There is no need to use Decontamination Area (REA). Patient can be seen in the ordinary emergency section. If medical and surgical emergency exists, it has to be attended first.

    - Obtain detail history of circumstances of exposure
    - Perform comprehensive physical examination. Systematic examination of each system should be done and recorded on a chart. Both normal and abnormal findings are recorded.
    - Proceed to laboratory investigations if history indicates that patient was exposed to a significant amount of radiation.

- Blood Investigation:

    - Complete blood counts, including absolute lymphocyte count, total white blood count, RBC and platelets. Repeat every 6 hours for the first 48 hours, then daily for one week.
    - Blood group and cross matching
    - Blood for cytogenetic study: 10ml **(please refer Appendix 14)**
    - A total of 30 ml blood sample is adequate for all the investigation.

- Estimate the dose received by the patient. Dose estimate is done based on history, symptoms, physical examination and laboratory investigation particularly the lymphocyte count. If the dose is estimated to be more than 100 rad, admit the patient.

Cytogenetics Studies

The Institute for Medical Research (IMR), which is nearby, will be utilised when there is a need for cytogenetic studies and whole body counts. This study can also be performed at **Malaysia Nuclear Agency** in Bangi, which is only 20 kilometres away from Kuala Lumpur. Radiation analysis of contaminated samples can also be performed here.

The floor plan, which shows the suggested patient flow and the suggested area to be used for decontamination of radioactive materials (designated **ERTA**) in the Emergency Department HKL is shown in **(please refer Appendix 5).** The facilities required for use in **ERTA** are given in **(please refer *Appendix 6).***

7.6 MANAGEMENT IN THE WARD FOR INTERNAL CONTAMINATION

- Continue to estimate the dose if it is still not completed.
- Continue to monitor blood count for evidence of haemopoeitic depression.
- Prescribe symptomatic treatment to the patient based on the symptoms.
    i. Give anti emetic for nausea and vomiting.
    ii. Anxiolytic for anxiety
    iii. Replace fluid and electrolyte if significant diarrhea and vomiting have taken place.
    - If significant haemopoitec depression is demonstrated:
        i. Isolate the patient.
        ii. Use barrier Nursing, preferably Reverse Barrier Nursing or Laminar Air flow;
        iii. In severe haemopoitic depression, haemopoetic support using growth factor such as GM-CSF (Granulocyte Monocyte Colony

Stimulating Factor) and the G-CSF (Granulocyte Colony Stimulating Factor) can be considered.

iv. Consider platelet transfusion if the level of platelets falls below 30,000/microliter, preferably with irradiated platelets.

- Treat infection early if there are signs of infection developing.

i. Use broad spectrum antibiotic after bacterial 'work out' has been done;

ii. Consider antiviral agent if viral infection is suspected;

iii. Use antifungal for fungal infection e.g. Candida of the mouth and GIT tract.

iv. Anti helminthics if indicated.

7.7 PEDIATRIC POPULATION

- Special considerations for children:
  - Children are more vulnerable to chemical agents that are
  - absorbed through the skin or inhaled
- Children have special susceptibilities to dehydration and shock from biological agents :
  - Children cannot be decontaminated in an adult decontamination unit. A special shower unit which can accommodate one parent and one child should be made available. The parent or caretaker can then help perform decontamination for the children.
  - Children require different dosages of antidotes to many agents

- Children have unique psychological vulnerabilities, and special management plans are needed in the event of mass casualties and evacuation.

- For decontamination purpose, shower units that can house an adult (parent or guardian) and the children together should be made available. The decontamination techniques are otherwise the same only that the parent/guardian shall take part in helping the child to be decontaminated.

7.8 IODINE PROPHYLAXIS

- For nuclear reactor accidents, our main concern is radioactive iodine isotopes (mainly Iodine-129 and Iodine-131) which are products from fission process in the nuclear reactor. The short-lived isotopes of iodine are particularly harmful because the thyroid collects and concentrates iodide both radioactive as well as stable form. Absorption of radioiodine can lead to acute, chronic, and delayed effects. Acute effects from high doses include thyroiditis, while chronic and delayed effects include hypothyroidism, thyroid nodules, and thyroid cancer.
- Iodine prophylaxis has been shown to prevent cancer during the Chernobyl accident. The Russians then only distributed potassium iodide tablets to those living within 30 miles of the nuclear plant. Although iodine prophylaxis is recommended more for people living near the area of nuclear plants, during the Chernobyl accident, thyroid cancer accidents have been reported to be lower in Poland (300 miles from the site) which prescribed 18 million tablets to its population.
- The WHO recommends dose of 130mg Potassium Iodide for those >12 years old, 65mg for those between 3-12 years old, 32mg for those between 1-36 months old and 16mg for those less than 1 month old.

- The WHO does not recommend iodine prophylaxis for those who are more than 40 years old.
- Alternatively, if potassium Iodide tablets are not available, 2 mls of suspended solution of Potassium Iodide (SSKI) will provide 130mg of Potassium Iodide.
- Alternatively in situations where no Potassium Iodide tablets or SSKI is available, Lugol's Iodine may be used with good efficacy. 1.3 ml of 5% Lugol's iodine (which is the standard solution available in hospital pharmacies in Malaysia) will provide 130 mg of Potassium Iodide. Potassium perchlorate is used for those with allergic to iodine.
- The IAEA guideline only recommends Iodine prophylaxis when the avertable radiation dose is 100mSv.
- Temporary Evacuation is recommended if the avertable dose is 50-100mSv whereas sheltering (stay in home with windows closed) if the avertable dose is 10mSv.

APPENDICES

Appendix 1

Table 1: Estimated Absorbed Dose Based on Minimal Lymphocyte Counts within 48 hours Following Exposure (reference : Adapted from Mettle, FA and Voelz, GL, New England Journal of Medicine, 2002)

Estimated Absorbed Dose (Gy)	Lymphocyte Counts (per mm^3)
0-0.4	>1500
0.5-1.9	1000-1499
2.0-3.9	500-999
4.0-7.9	100-499
>7.9	<100

Table 2: Sign, symptoms and Recommended Disposition of Exposed Patients

Estimated Whole Body Dose (Gy)	Onset of Vomiting	Percent of cases	Diarrhea Severity and Onset
<1	none	-	none
1-2	>2 h	10-50%	none
2-4	1-2 h	70-90%	none
4-6	<1 h	100%	Mild 3-8 h
6-8	<30 min	100%	Heavy 1-3 h
>8	<10 min	100%	Heavy <1 h

Estimated Whole Body Dose (Gy)	Headache Severity and Time of Onset	Fever	Level of consciousness
<1	none	None	Normal
1-2	slight	None	Normal
2-4	mild	Mild 1-3 h	Normal
4-6	Moderate 4-24 h	Moderate to high 1-2 h	Normal
6-8	Severe 3-4 h	High < 1 h	May be reduced
>8	Severe 1-2 h	High < 1 h	Unconscious- may be for only seconds or minutes(greater than 50Gy incidence is 100%)

Appendix 2

Types of Radioactive Materials and Types of Emissions

Nuclide	Physical Half-life	Emissions
^{3}Hydrogen(Tritium)	12 years	β-
^{60}Cobalt	5.27 years	β-, γ
^{90}Strontium	28 years	β-
^{131}Iodine	8 days	β-, γ
^{137}Cesium	30 years	β-, γ
^{192}Iridium	74 days	β-
^{235} Uranium	7×10^{8} years	α, γ
^{238}Uranium	4.5×10^{9} years	α, γ
^{238} Plutonium	88 years	γ, α
^{239} Plutonium	2.4×10^{4} years	γ, α
^{241} Americium	458 years	α
^{99m}Technetium	6 hours	γ
^{67} Gallium	78 hours	γ
^{32}Phosphorous	14 days	β-
^{90} Yttrium	2.67 days	β-, γ
^{51} Chromium	27.8 days	γ
^{125} Iodine	60.1 days	γ

Appendix 4

Items required by MERT in Preparation to Enter to Radiation Site include:

a) Protective clothing that includes gowns, glove, boots, fire turnout gears, coats or jackets, masks and shoes cover.

b) Self-contained breathing apparatus.

c) Radiological survey instruments such as a multipurpose Geiger Counter

(alpha, beta, gamma), film badges and pen dosimeter.

d) First aid kits, which include bandage, common first aid medications and blankets or sheets.

e) Replacement fluid for intravenous therapy.

f) Trolleys or stretchers for transporting patients.

g) Facilities for Cardiopulmonary resuscitation (CPR).

Equipment required by Radiation Safety Officer

a) Beta gamma detector.

b) Alpha detector

c) Extra batteries for detectors

d) “Radioactive” tape labels to mark containers holding contaminated specimens or swabs.

e) “ Post decontamination “ tape labels to mark containers holding relevant swabs.

Appendix 5

USING THE GEIGER – MULLER COUNTER (e.g. Ludlum 14-C)

- Get the Geiger Counter and batteries from storage.

- This instrument can detect alpha, beta and gamma radiation.

- Prepare the instrument and determine background level:

A. PREPARING THE METER

a) Position the Geiger counter with the meter away from you. The battery compartment lid will open toward you. The lid is labeled a ' + ' (on the left) and ' – ' (on the right).

b) Put the batteries into the meter: the left-hand battery goes – down, the right-hand battery goes + up.

c) Close and latch the battery compartment.

d) Turn the range switch to the highest range e.g. X 1000 position.

e) Press the 'bat' button (the meter needle should move to area on scale marked battery, indicating the batteries are good). If the batteries are weak, replace with new 2 D-cells. Recheck condition of batteries.

f) Turn the 'F/S' switch to 'S' (slow).

g) Turn the 'audio' switch 'ON'.

B. MEASURING THE BACKGROUND RADIATION

a) Check that the 'F/S' switch is on S (slow).

b) Move the range switch to the X O.1 position.

c) Remove the probe cover.

d) Measure the background radiation for 60 seconds: write down the reading. Since background radiation varies with time, it may be desirable to make several counts and average the results. Record the reading in units of counts per minutes or mR /hr.

e) If the patient is already in the treatment area, move to a point at least 10 ft. from the patient to make baseline measurement.

f) Expect a reading of 40-100 counts/minutes on the top scale of the meter or a reading of 0.2 (XO.1 position) mR/ hr on the middle scale.

g) Record the background reading.

C. SURVEYING THE PATIENT AND RECORDING RESULTS IN CHART

A patient survey can be done simultaneously with other emergency procedures provided there is no interference with needed emergency care.

a) Move the 'F/S' switch to F (Fast response).

b) Set the instrument selector switch to the most sensitive range of instrument (0.1).

c) Holding the probe approximately ½ to 1 inch from the patients akin, systematically survey the entire body from head to toe on all sides:

i. Move the probe slowly (about 1 inch per second).

ii. Do not let the probe touch anything.

iii. Try to maintain a constant distance.

iv. Pay particular attention to wounds, orifices, body folds, hairy areas and hands.

v. Note the alpha radiation cannot be detected through even a thin film of water, blood, dirt or clothing.

d) An increase in count rate or exposure rate above background indicates the presence of radiation.

i. Locate the point that procedures the most clicks. Turn the F/S switch to S. take a reading at this location.

ii. When necessary, adjust the range of the instrument by moving the range selector switch.

e) Document the time and radiation measurements on an anatomical scale drawing; each subsequent survey result should be documented.
If not using on anatomical scale drawing, indicate the location of the reading; the range the meter is set at; and which scale the reading is from, as well as a meter reading.

f) In general areas that register more than twice the background radiation level are considered contaminated. For accidents involving alpha emitters, if the reading is less than twice the background radiation level, the patient is not contaminated to a medically significant degree. If the accident circumstances indicate that an emitter (such as plutonium) or low energy beta emitter could be a contaminant, a health physicist should always be consulted.

D. ENDING RADIATION SURVEY

a) Switch off the meter

b) Replace the cap on the meter probe

c) Take the batteries out

d) Put the Geiger Counter back in its case

Appendix 6

PREPARING THE AMBULANCE AND TRANSPORTING

RADIATION VICTIMS TO THE HOSPITAL

Transporting patients to a hospital does not require a specially designed ambulance. Ordinary ambulance can be used provide that some preparation are made. Some items are required and these are stretchers, blankets, plastic mats, gloves and gowns for use of patients, patient attendants and ambulance driver as below:

Suggested Equipment for Emergency Vehicles Responding to Radiation Accidents.

- Protective clothing (surgical glove)
- Multipurpose GM survey meter (alpha, beta, Gamma) with probe and fresh batteries.
- Surgical or disposable gloves.
- Plastic bags, trash bags and ties.
- Full sized sheets or blankets.
- Rope or barrier tape to mark the contaminated area.
- Radiophone communication system (preferably).

Appendix 7

SUPPLIES NEEDED FOR EMERGENCY DEPARTMENT PREPARATION

1. **Emergency Department Preparation**

a) Rolls of 3 to 4 feet wide brown wrapping paper (butcher paper) of square absorbent padding sufficient to cover the entire floor of the decontamination room.

b) Rolls of 2-inch wide masking tape to secure the floor covering, tape decontamination room, and make a control line door.

c) Rope to delineate route from ambulance entrance to decontamination room.

d) 'Caution – Radiation Area' signs to be placed on rope and on decontamination room

2. Decontamination Room

a) Decontamination table with waterproof cover or other specially designed table;

b) Three 5 gallon containers for wash water;

c) Three large waste containers lined with plastic bags;

d) Various sizes of plastic bags for samples, clothes etc;

e) Cotton-tipped applicators;

f) Stopper containers for swabs of contaminated areas;

g) Small lead storage containers (“pigs”) for holding radioactive foreign bodies removed from wounds obtained from Nuclear Medicine Department;

h) Chart with drawing of patient outline, front and back, for recording contaminated areas;

i) Solution or materials for decontamination:

   i. Sterile saline
   ii. Sterile water
   iii. Sodium hypochlorite or household bleach
   iv. Povidone iodine solution or other surgical soap
   v. Abrasive soap
   vi. Mixture of one-half powdered detergent and one- half cornmeal kept air tight or refrigerated.

All necessary emergency medical supplies and equipment (suction, oxygen, airways, intubation’s tube, IV solutions, etc.) ;

Sheet, blankets, towels and patient gowns.

Appendix 8

Decontamination Team

a) Scrub suit
b) Gowns
c) Surgical hoods
d) Masks
e) Surgical Gloves of various sizes
f) Waterproof shoe covers
g) Film badges
h) Dosimeters
i) Rubber or plastic aprons (lightweight, not lead-lined, X-Ray type)
j) Masking tape or equivalent

Radiation Safety Officer

a) G-M Survey meter
b) Ionization chamber
c) Alpha detector (optional)
d) Extra fresh batteries for survey meters
e) Radioactive labels or sticker to mark containers holding contaminated specimens or swab.
f) Wax or felt pens to mark labels.

Appendix 9

SAMPLES TO BE TAKEN

All samples must be placed in separate, labeled containers that specify name, date, time of sampling, area of samples and size of care samples, medical legal and often post-accident gations require that no blood, urine, faeces or other samples taken in the emergency treatment period be period be disposed of without authorization.

SAMPLES NEEDED	WHY?	HOW?
In all cases of radiation injury :		
CBC and differential STAT (Follow with absolute lymphocyte counts every 6 hours for 48 hours for when history indicates possibility of total body irradiation)	To assess the radiation dose: initial counts establish a baseline, subsequent counts reflect the degree of injury	Choose a non-contaminated area for venipuncture; cover puncture site after collection
Radiation urine analysis	To determine if kidneys are functioning normally and establish a baseline of urinary constituents especially important if internal contamination is a possibility	Avoid contaminating specimen during collection; if necessary, give the patient plastic gloves to wear for collection of specimen Number 1, with date and time
When external contamination is suspected:		
Swab from body surface	To assess possibility of internal contamination	Use separate saline or wipe the inner aspect of each nostril, each ear, nostril, mouth, etc.

SAMPLES NEEDED	WHY?	HOW?
Swab from wounds	To determine if wounds are contamination	Use moist or dry swabs to sample secretions from each wound, or collect a few drops of secretion from each using a dropper or syringe for wounds with visible debris, use applicator or long tweezers or forceps to transfer samples to specimen containers which are placed in lead storage containers (pigs)
Skin wipes	To localize contaminated areas	Use filter paper smear pads, or compress to wipe sample areas 10cm x 100cm in size
When internal contamination is suspected:		
Urine: 24 hours specimen x 4 days	Body excreta may contain radio nuclides if internal contamination has occurred	Use 24 hours urine collection container
Faeces x 4 days	Body excreta may contain radio nuclides if internal contamination has occurred	Save excreta in plastic containers in freezer
Vomitus	Body excreta may contain radio nuclides if internal contamination has occurred	Save excreta in plastic containers in freezer
Sputum	To assess respiratory tract contamination if inhalation of contamination as a possibility	Use a 5-percent propylene-glycol aerosol to get a deep cough specimen.
Serum creatinine	To assess kidney function if chelation is indicated	Clinical chemistry
Other samples needed		
All irrigating fluids	Radiological assessment	Save in sealed and labelled, glass or plastic-lined containers.

Appendix 10

DECORPORATION

The reduction of the amount of radioactive material in the body or fluids by using specific drugs or methods. Should attempt to begin this within one to two hours of the accident.

Reduction of Absorption and Deposition:

Blockage

Reduction of uptake by the organ by fixation at the site of entry.

Trapping

Trapping of radioactive material during translocation.

Enhanced elimination or secretion

This is usually best achieved by early and prompt administration of diluting and blocking agent.

THERAPEUTIC OPTIONS FOR DECORPORATION

Wound Irrigation and Excision

Once radioactive contamination of wound has been located it should be removed with:

i. Adequate irrigation with saline, free bleeding, venous occluding or hydrogen peroxide.

ii. Block excision is usually more effective than local would debridment. Primary wound closure may be done after checking for residual activity.

Blocking and Diluting Agents

A blocking agent to a specific tissue with the stable element, thereby reducing the uptake of the radionuclide.

e.g. Sodium or potassium iodide is used to block thyroid gland uptake of Radioactive Iodide.

Mobilising Agents

These are agents that increase the natural turnover process in the body, thus inducing the release of radioisotopes from the body.

E.g. Propylthiouracil directly interferes with the oxidation of iodine in the thyroid gland and blocks the formation of thyroid hormone or the use of Ammonium Chloride or injection of parathyroid extract to mobilize Strontium.

Chelating Agents

Chelating is the process by which organic compounds exchange less firmly bonded ions for other inorganic ions to form a stable complex. Chelated compounds are usually excreted more rapidly.

e.g. Calcium EDTA, Penicillamine

Appendix 11

REDUCING INTERNAL CONTAMINATION AND INCORPORATION

Reducing Gastrointestinal Absorption

Contamination of the GIT is due to ingestion of Radioactive material that may occur as a primary event or may be secondary to ingestion of inhaled material that reaches the pharynx by mucocilliary action.

The following steps are taken to reduce radiation.

i. Reducing the load.

   Gastric lavage

   Naso-gastric suction

ii. Reducing absorption

   Reduced GIT transit time.

iii. Isotopic dilution

   Resins.

iv. Specific agents.

   Binders.

Lung Lavage

Deposition of Radioactive material in the lung is one of the more common types of accidental exposure of humans to radionuclides. Insoluble particles, once inhaled into the lung may be mobilized and translocated to other organs at a low rate over many months or years.

Lavage is of benefit for those individuals who have inhaled relatively insoluble radionuclides.

This has to be done under general anaesthesia and a rigid bronchoscope should be used to introduce the isotonic saline.

Lavage has been found to reduce radiation pneumonitis and early death that may result from Plutonium inhalation. Done serially, it can remove up to 90% of the lung burden of Plutonium.

Use on other form of radiation inhalation is not well documented and one needs to assess the risk-benefit ratio carefully.

APPENDIX 12

THERAPY FOR SELECTED ELEMENTS

RADIOACTIVE IODINE

25% of an oral dose will be deposited in the thyroid gland within six hours. Therefore, treatment should be made as soon as possible. Blocking agents or Binders should be used.

Treatment

Potassium Iodide 130mg p.o **OD**, ideally before expected accident or if not, as soon as possible, repeat dose daily as long as the contamination lingers in the environment.

STRONTIUM AND RADIUM

Treatment

Oral ingestion: give 10 – 20 gms of powder of Calcium Alginate or sodium alginate in 30 cc vial, add water and drink.

Open Wound: sprinkle 1 gm of Calcium Alginate.

If radium has been swallowed, give barium sulphate orally as it will help to precipitate the radium.

CAESIUM

This is rapidly absorbed from the Gut and Respiratory system and deposited in the muscle and soft tissues. Thus, treatment has to be rapid.

Treatment

1gm. Of Prussian Blue in water to be given TDS. Also consider lavage or purgative.

TRITIUM

It is easily oxidized to titrated water. Rapidly absorbed via GIT and Respiratory system. It may also be absorbed via intact skin. It is evenly distributed in the body.

Treatment

Forced diuresis and increased oral or intravenous fluids.

PLUTONIUM

This is an alpha emitting isotope. It is dangerous when it is inhaled or if it contaminates an open wound.

When it is inhaled it will be either transported to the bone and liver or transported to regional lymph nodes after being phagocytosed by lymphocytes.

Treatment

Ingestion

Immediate I/V over 1 hour diethylene-triamine-penta-acetate (DTPA) 1gm in 250ml normal saline or 5% dextrose in water once daily (To be done till there is no more plutonium (Pu) excreted in the urine) This may take several days to a week without toxic effects

Inhalation

Nebulised DTPA 1gm. over 15 to 30 mins daily. Also lung lavage.

NON-SPECIFIC DECORPORATION

1. Naso-gastric tube suction
2. Gastric lavage
3. Antiacids
4. Laxatives
5. Activated Charcoal
6. Specific antidotes

APPENDIX 13

PATIENT RECORDS AND DOCUMENTATION

In addition to the medical records for all hospital admissions, there are other numerical and descriptive data, which includes:

a. a description of the accidents;

b. radiation survey readings at site of accident and from follow-up;

c. photographs of accident site and of the patient's radiological involved areas;

d. an estimate of dose

e. descriptions of samples and time of sampling;

f. the findings of all assays and analytical procedures;

g. an effectiveness estimate of decontamination measures; and

h. a record, preferably photographic, of pre-exiting lesions, scars, rashes and the like.

This information will be helpful for developing a prognosis and for an investigation into the underlying cause of the accident.

APPENDIX 14

PROCEDURE FOR COLLECTING BLOOD FOR DOSIMETRY STUDY BY MINT / IMR CYTOGENETIC GROUP

(Lymphocyte sampling procedure kit inserts)

(This package contains all materials required for blood collection including: 10 cc RED stoppered (sterile) vacutainer tubes, vacutainer sleeve and needles, heparin (1000 units/cc, and coolant packs)

1. To ensure successful culturing of cells for cytogenic evaluation. It is imperative that, the lab receives blood samples as soon as possible after collection (within a maximum period of 24 hours).

2. Immediately before blood collection, add 0.1cc heparin to each vacutainer.

3. Draw three tubes of blood, approximately 10cc / tube, to be sent to Cytogenetic Laboratory (Note: we provide five tubes in the event that some of the tubes may have lost their vacuum)

4. Immediately after blood collection, gently invert vacutainer tubes to mix blood and anticoagulant – (this is very important, we cannot use clotted blood in our studies.)

5. Blood samples must be kept cool (NOT FROZEN). Wrap vacutainers in a protective material such as gauze, Kleenex, etc., surround with coolant packs and pack in our insulated container. Secure tubes with paper or other packing material to prevent breakage during handling.

6. Send samples as soon as possible to:

Cytogenetic Laboratory

Agensi Nuklear Malaysia (ANM)

Bangi, Selangor

Or

Institute of Medical Research

Bahagian Cytogenetic

Jalan Pahang

Kuala Lumpur

CHECK LIST

Five (0cc) sterile RED stoppered vacutainer tubes.

Vacutainer sleeve

Vacutainer needles

Upohn sodium heparin (1000 units/ml)

Coolant packs

Address labels

Consent forms

GLOSSARY

Absorbed dose	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place in interest. The unit of absorbed dose is the Gray, while the Dose Equivalent which is the product of absorbed dose and quality factor and expressed in sievert.
Alpha particle	A specific particle ejected spontaneously from the nucleus of some radioactive elements. It is identical to a helium nucleus, which has an atomic mass of 4 and an electrostatic charge of 2, it has low penetrating power and short range. The most energetic charge alpha particle will generally fail to penetrate the skin. The danger occurs when matters containing alpha-emitting radio nuclides are introduced into the lungs or wounds.
Atom	The smallest particle of an element which cannot be divided or broken up by chemical means. It consists of a central core called the nucleus, which contains protons and neurons. Electrons revolve in orbits around the nucleus.
Background Radiation	The radiation in man′s natural environments including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of men and animals. It is also called natural radiation. Man-made sources of radioactivity contribute to total background radiation levels. Approximately 90 percent of background radiation from man-made sources is related to the use of ionizing radiation in medicine and dentistry.

Beta particle	A small particle ejected spontaneously from a nucleus of a radioactive element. It has the mass of an electron and has a charge of minus one or plus one. It has medium to intermediate penetrating power. Symbol β^- or $\beta+$
Charged particle	An ion, an elementary particle that carries a positive or negative electrical charge.
Controlled area	An area where entry, activities and exit are controlled to ensure radiation protection and prevent the spread of contamination.
Decontamination	The reduction or removal of contaminating radioactive material from a structure, area, object or person.
Dose	A general term for denoting the quantity of radiation or energy absorbed. If unquantified, it refers to absorbed dose. For special purposes it must be appropriately qualified. If used to represent exposure expressed in roentgens (R), it is a measure of the total amount of ionization that the quantity of radiation could produce in air.
Dose rate	The absorbed dose delivered per unit time. It is usually expressed as mSv per hour, or in multiples or submultiples of this unit. The dose rate is used to indicate the level of hazard from a radioactive source.
Dosimeter	A small, pocket size ionization chamber used for monitoring

	radiation exposure of personnel. Before use it is given a charge, and the amount of discharge that occurs is a measure of the accumulated radiation exposure.
Exposure	A quantity used to indicate the amount of ionization in air produced by x-rays or gamma radiation. The unit is the roentgen (R).
Geiger counter, Or G-M meter	An instrument used to detect and measure radiation. The detecting element is a gas-filled chamber operated by a voltage whose electrical discharge will spread over the entire anode when triggered by a primary ionizing event.
Ion	Atomic particle, atom or chemical radical bearing an electrical charge, either negative or positive.
Monitoring	Periodic or continuous determination of the amount of radiation or radioactive contamination present for the purpose of radiation protection.
Radiation	The energy propagated through space or through a material medium in the form electromagnetic waves. Radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation. Particulate radiation involves particles such as alpha and beta radiation.

rem	Roentgen-equivalent man is a unit of radiation dose equivalent which is numerically equal to the absorbed dose multiplied by the quality factor (Q), the distribution factor, and any necessary modifying factors. This unit has been replaced by the sievert (100 rem = 1 Sv).
Roentgen	The unit of exposure from x – rays or gamma rays.
Sealed source	A radioactive source, sealed in a impervious container, to prevent contact with and dispersions of the radioactive material under the conditions of use and wear for which it is designed. Generally used for radiography or radiation therapy.
X-rays	Penetrating electromagnetic radiation whose wave lengths are shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a vacuum.

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IN THE EVENT OF RADIATION ACCIDENTS:

PERSONS TO CONTACT FOR ANY ENQUIRIES

- **DATUK DR ALZAMANI MOHAMMAD IDROSE**
  (EMERGENCY PHYSICIAN & DISASTER MEDICINE SPECIALIST)
  : 013-4217234
- **MOHD AZHAR MUSA**
  (HKL'S RADIATION PROTECTION OFFICER) : 019-6704258
- **ZUNAIDAH SAID : 018-2121393**
  (RADIATION PROTECTION SUPERVISOR)
- **NOOR DIANA DOLMAT : 017-6999941**
  (RADIATION PROTECTION SUPERVISOR)
- **NURUL HIDAYAH MOHD AZEMI : 011-16332360**
  (RADIATION PROTECTION SUPERVISOR)

The above person's number valid until 31st December 2018

“The discovery of nuclear chain reaction need not bring about the destruction of mankind, any more than did the discovery of matches”

Albert Einstein