KARNATAKA RADIOLOGY EDUCATION PROGRAM

RADIATION PROTECTION

HOW IS RADIATION MEASURED?

The **genetically significant dose (GSD)** is defined as the dose that, if received by every member of the population, would be expected to produce the same total genetic injury as the actual doses received by the various individuals.

The **roentgen (R)** is defined as a unit of **radiation exposure** that will liberate a charge of 2.58×10^{-4} coulombs per kilogram of air.

The **rad** is the unit of **absorbed dose.**

International System of Units (SI) for radiation measurement is the official measurement is **'Gray' (Gy) for absorbed dose** and '**Sievert' (Sv) for equivalent dose**.

The **rem** is unit of **absorbed dose equivalent.** The rem is a unit used only in **radiation protection.**

WHAT THESE DIFFERENT DOSES CAN TELL US:

Absorbed dose – used to assess the potential for biochemical changes in specific tissues.

Equivalent dose – used to assess how much biological damage is expected from absorbed dose.

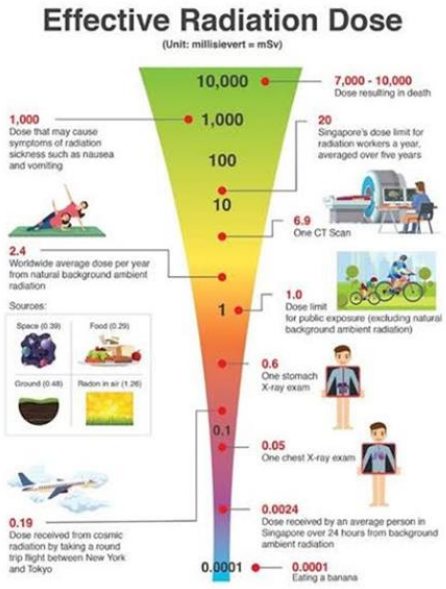
Effective dose – used to assess the potential for long-term effects that might occur in the future.

POPULATION EXPOSURES TO RADIATION:

Effective dose equivalent (H_E) – Purpose is to relate exposure to risk.

Natural Radiation: Arises from external and internal sources.
External sources – Cosmic radiation from outer space and terrestrial gamma radiation from radionuclides in the environment.
Internal sources – Radionuclides from within the body.

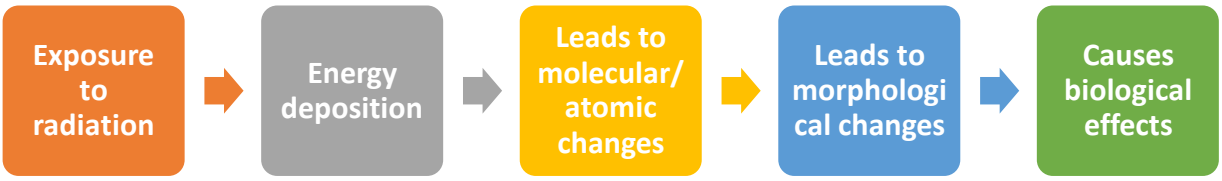
Medical Radiation: Arises from diagnostic medical x-rays and nuclear medicine.



Diagnostic imaging modality	Effective dose (mSv)[a]	Equivalent number of chest X-rays resulting in the same effective dose	Following ranges are accepted (based on equivalent number of chest X-rays)
Chest X-ray	0.02	1	1
Cranial X-ray	0.07	3.5	0–10
Pelvic X-ray	0.7	35	10–50
Abdominal X-ray	0.7	35	10–50
Cranial CT	2.4	120	50–200
Chest CT	7.8	390	200–500
Abdominal CT	12	600	>500
Pelvic CT	10.5	525	>500
Abdominal US	0	0	0
Abdominal MRI	0	0	0

BIOLOGICAL EFFECTS OF RADIATION

- Effects depend on type of tissue and upon dose level.
- More rapidly a cell is dividing, the greater is the radiosensitivity.



Human Responses To Ionizing Radiation

1. EARLY EFFECTS: Within minutes or days
2. LATE EFFECTS: 6 months or more

Factors Affecting Length Of Latency Period

1. RADIATION
   a. Type of radiation (X rays, gamma rays)
   b. Dose of radiation
2. TYPE OF CELLS
   a. Rate of division

EARLY EEFECTS OF RADIATION

Acute Radiation Syndrome

- Prodromal period: Immediate response
- Latent period: Symptom free
- Manifest Illness:

Hemotologic syndrome: Hemotological depression (reduction in RBC, WBC and platelets)

GI syndrome: Desquamation of Intestine lining cells.

CNS syndrome: Elevated fluid content of brain

Local tissue damage to skin and gonads

Cytogenetic changes

- **LD 50/60:** Dose of radiation to whole body that will result in death withing 60 days to 50% of irradiated subjects.
- **SED 50 (SKIN ERYTHEMA DOSE 50):** Skin erythema in 50% of irradiated.

LATE EFFECTS OF RADIATION

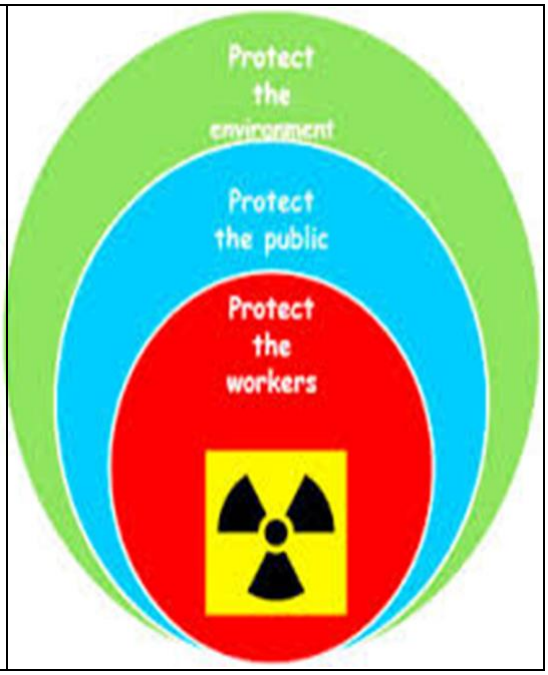
- Leukaemia: Latent period of 4-7 years, at risk period of 20 years.
- In children – ALL
- In adults – CLL, AML, CML
- Other malignancies: Bone, lung, thyroid, breast, skin, liver.
- Shortening of life span.
- Genetic damage:

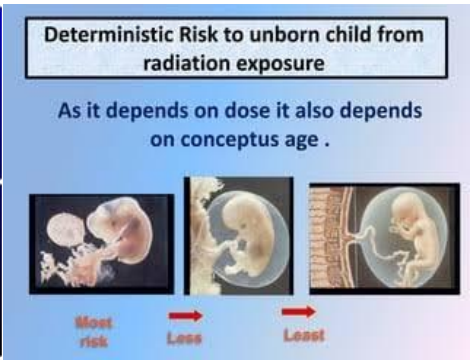
Doubling dose – Dose of radiation that will produce twice the frequency of genetic mutations is genetically significant dose.

DOSE-LIMITING RECOMMENDATIONS

The National Council on radiation Protection and Measurements (NCRP) makes recommendations on limits of exposure to ionizing radiation.
There are four classes of individuals:

1. Occupationally exposed individuals: An individual's lifetime effective dose equivalent in rems should not exceed the value of his or her age in years.
2. The general public: The dose limit for occasionally exposed is 0.5 rem/year, or one tenth of the maximum permissible dose for the occupationally exposed.
3. Trainees under 18 years of age: Annual effective dose equivalent of less than 0.1 rem (1 mSv).
4. Embryo-fetus: Total dose equivalent limit (excluding medical exposure) of 0.5 rem (50mSv) for embryo-fetus. Once pregnancy becomes known, exposure of embryo-fetus should be no greater than 0.05 rem (0.5mSv) in any month (excluding medical exposure).





REGULATORY BODIES FOR RADIATION SAFETY

- Establishes norms for protection against radiation.
- Recommends dose limits for radiation workers.
- Recommends dose limits for general public

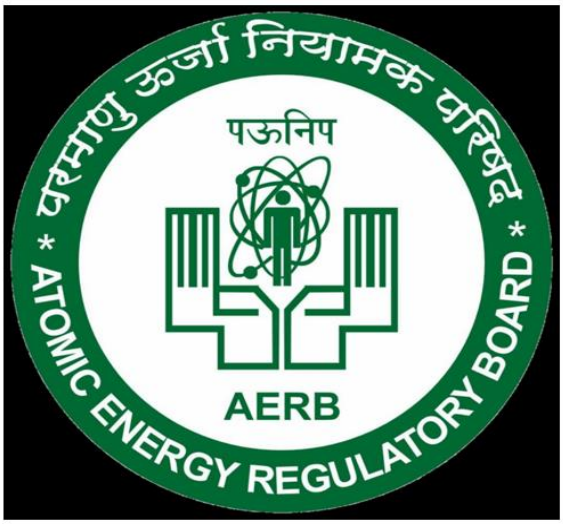
INTERNATIONAL REGULATORY BODY: The **INTERNATIONAL COMMISION FOR RADIATION PROTECTION (ICRP,1928)** – To provide an appropriate standard of protection for man without unduly limiting the beneficial practices giving rise to radiation exposure.

National counterpart of ICRP is the **ATOMIC ENERGY REGULATORY BOARD (AERB)** – To ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health and environment.

Role of AERB

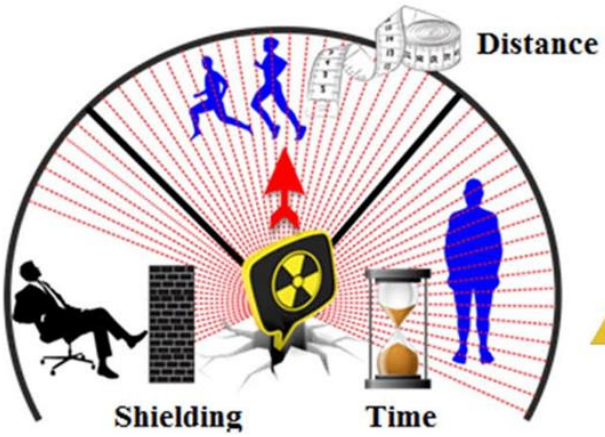
- Recommends and lays down guidelines on
- Specifications of medical X ray equipment for given room layout.
- Regarding work practices in the X-ray department.
- Protective devices use and maintenance.
- Responsibilities of radiation works, employer and radiation safety officer.
- Exercises a regulatory control on the
- Approval of new models of X-ray equipment.
- Layout of any new proposed X-ray installation.
- Regulatory authority for
- Registration and commissioning of new X-ray equipment.
- Inspection and decommissioning of X-ray installation.
- Certification of RSO and service engineers.
- Imposing penalties on any person contravening the rules.

Radiation Safety Officer – trained AERB certified and educated person with respect to: radiation protection, radiation physics, Radiation biology, Instrumentation, Dosimetry and Shielding design.



GENERAL PRINCIPLES OF RADIATION PROTECTION

- **Justification of a practice:** To evaluate the **BENEFIT TO RISK RATIO**, most appropriate examination to be performed which can potentially contribute in minimizing radiation exposure to the patient.
- **Optimization of radiation protection:** To administer a radiation dose which is **AS LOW AS REASONABLY ACHIEVABLE**, avoiding repeat exposures.
- **Dose limitation: TIME – DISTANCE – SHIELDING t**riad
- Keep the time of exposure as short as possible.
- Use of pulsed progressive fluoroscopy: Reduces patient dose to a factor of 0.1 or less.



ASPECTS OF SHIELDING IN DIAGNOSTIC RADIOLOGY

- **X-RAY TUBE SHIELDING.**
- **ROOM SHIELDING.**
- **X-ray equipment room.**
- **Patient waiting room.**
- **PERSONNEL SHIELDING.**
- **PATIENT SHIELDING (of organs not under investigation).**

X-RAY TUBE SHIELDING: Tube housing is lined with thin sheets of lead which protects from leakage and scattered radiation. Limit leakage radiation exposure rate to 0.1 R/hr at 1m from the tube anode.

ROOM /STRUCTURAL SHIELDING:

Protective barriers: The lead lined walls of Radiology Department. Designed to protect individuals located outside the X-Ray rooms from unwanted radiation.
Primary barrier: One which is directly struck by the primary beam.
Secondary barrier: One which is exposed to secondary radiation either by leakage from x-ray tube or scattered radiation from the patient.

Shielding of X-ray room is influenced by nature of occupancy.

- **Control area:** Area routinely occupied by radiation workers who are exposed to occupational dose. Shielding should be such that it reduces exposure in that area to < 26 mC/kg/week.
- **Uncontrolled areas**: Areas not occupied by occupational workers. Shielding should reduce the exposure rate to <2.6 mC/kg/week.

AERB GUIDELINES

For X-ray Examination Room shielding

- Location: 18m^2 for general purpose radiography and conventional fluoroscopy.
- Primary barrier: 35 cm thick brick/ equivalent.
- Secondary barrier: 23 cm thick brick/ equivalent.
- Shielding equivalent for doors and windows: 23 cm thick brick / 1.7mm lead.
- Unshielded openings: Above a height of 2m from the finished level outside the room.

X-ray control room

- Walls and viewing window of control booth should be shielded with lead equivalent of 1.5mm.
- Primary beam should not fall directly.
- Radiation to be scattered twice.

For patient waiting area

- Outside the X-ray room.
- Suitable warning signal (RED LIGHT) and warning placard should be displaced.

For CT Suite

- 25m^2 for Gantry of CT.
- Adequate shielding for walls, floor and roof.
- Additional thickness of 2.5mm lead/ 162mm of concrete.

PERSONNEL SHIELDING

- Remain in radiation environment only when necessary.
- Maintain distance.
- Wear shielding apparel (0.5mm lead equivalent) like lead aprons, lead glasses, lead gloves and thyroid shields.

PATIENT SHIELDING – Protect organs not under investigation, proper positioning and use of gonad and thyroid shields.

RADIATION MONITORING DEVICES

- Radiation detection devices.
- Radiation measuring dosimeters.
- TLD badges.

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Ref: Christensen's Physics of Diagnostic Radiology, Radiopedia.