Challenges in Radiation Protection During Radiological Medical Procedures

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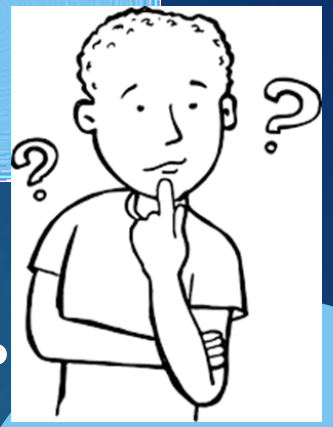
Topics covered in presentation

- Applications of ionizing radiation in medicine
- Regulatory requirements for radiation protection
- Issues of patient protection
- Initiatives of AERB
- Conclusion

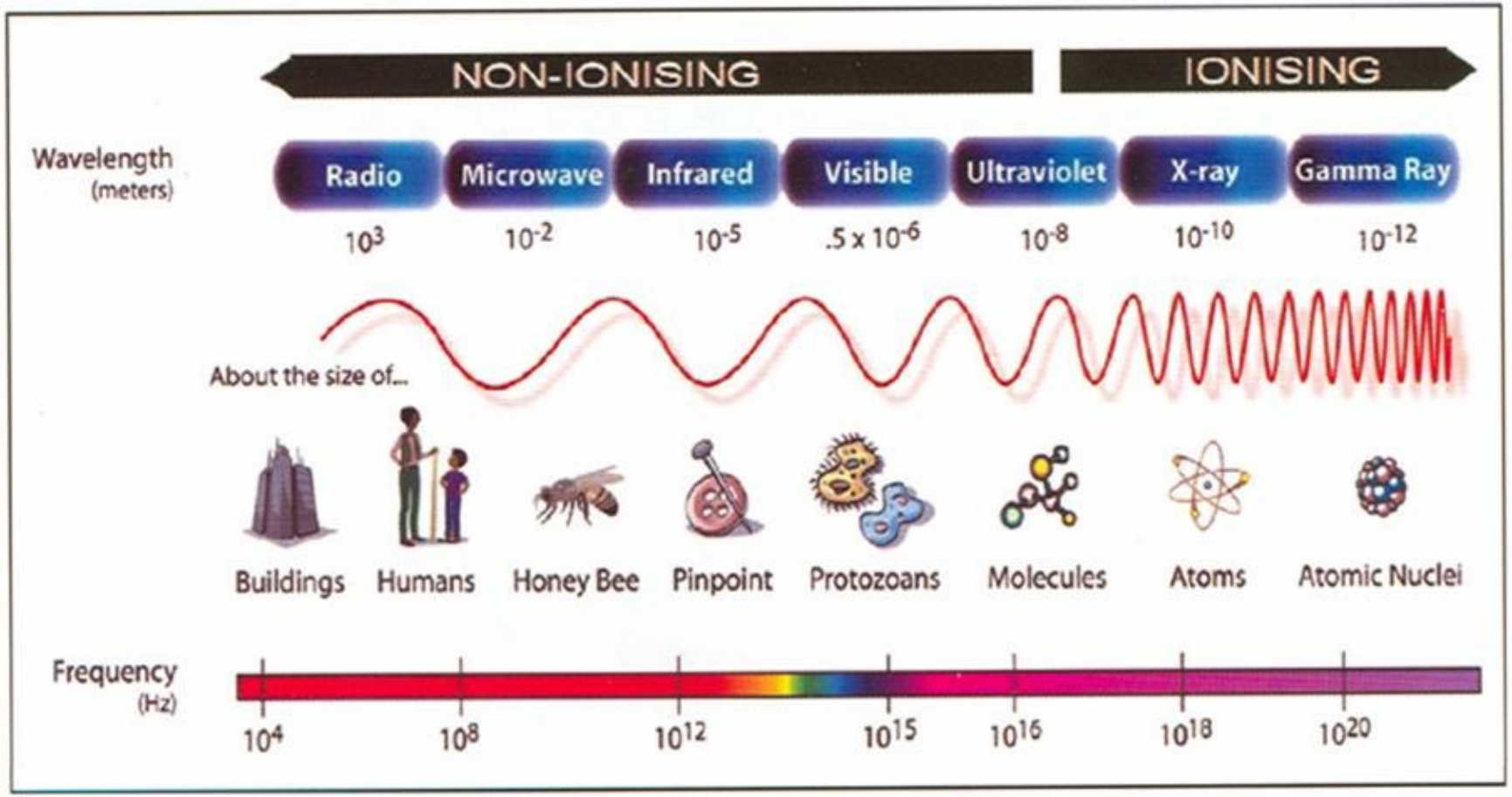


What is RADIATION…..

Is there Radiation in your room?

Yes, but not all forms of radiation are harmful !!!

Radiation and its Types



Radiation and its Types

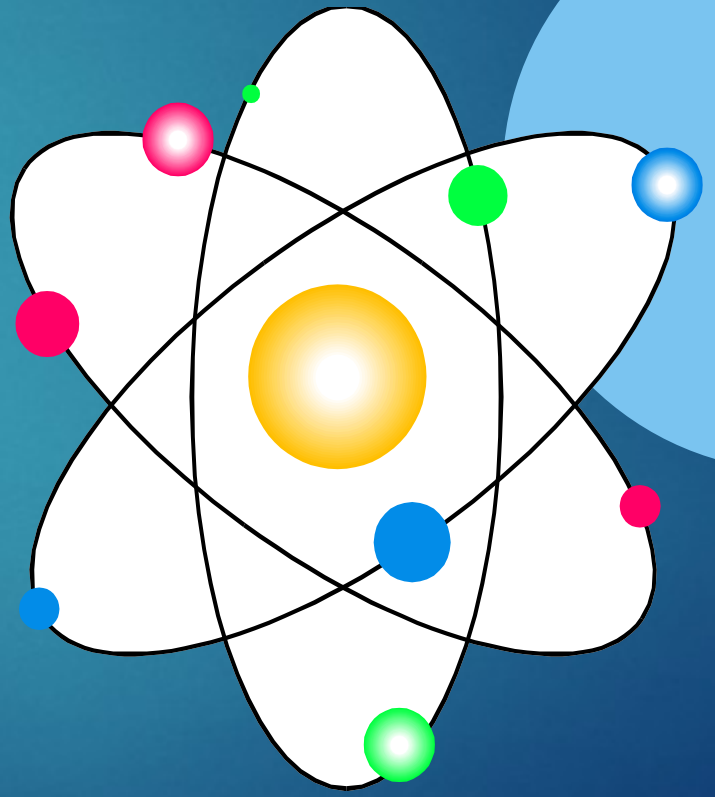
Radiation: Radiation is nothing but Energy in motion

We live in a sea of radiation. This includes

- **Non-Ionizing Radiation**: Radiation that does not have sufficient energy to remove an electron (ionize) from an atom. e.g.: Radio waves, microwaves, infrared radiation , visible light, lasers, ultraviolet light and radar.
- **Ionizing Radiation**: Radiation that has sufficient energy to eject electrons from atoms (i.e ionize atoms). e.g.: alpha particles, beta particles, neutrons, gamma rays, and x-rays.

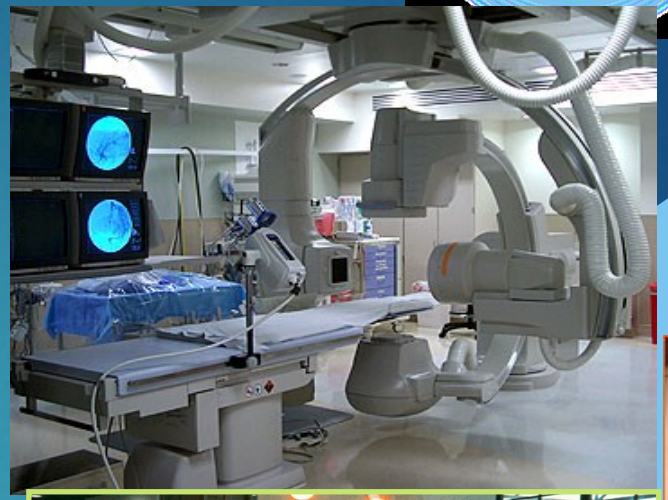
There are 4 main uses of ionizing radiation in Medicine

- Diagnosis
- Treatment
- Blood irradiation
- Sterilization of healthcare products



RADIATION IN MEDICINE

- Machine produced radiation from X ray tubes used in medical imaging
- Linear accelerators and equipment containing radioactive sources used in cancer therapy
- Radioactive materials used in nuclear medicine imaging and in some cancer therapy applications.



MEDICAL RADIATION FACILITIES IN INDIA

Medical Radiation Facilities in India

- **Radiotherapy centres : 410**
- **X-ray diagnostic equipment: 45,200**

  (Computed Tomography- 2339
  Interventional Radiology – 985)

- **Nuclear Medicine Centres – 236**

  (PET-CT – 125 , Gamma Camera – 163)

UNSCEAR 2008 Report

- An estimated 5.1 million courses of radiotherapy treatment were administered annually between 1997 and 2007.

Every year, 1 million new cancer cases are detected in India of which 40,000 cancer cases occur in children, more than 700,000 people dying every year and India accounts for 8 % of world cancer prevalence.

TMH, Mumbai Report

- An estimated 3.6 billion (3.1 medical and 0.5 dental) x-ray examinations were undertaken annually in the world between 1997 and 2007.

CT scanning accounts 43% of the total collective effective dose due to diagnostic medical radiology.

- Nuclear medicine includes all uses of unsealed radioactive sources for diagnostic and therapeutic purposes.

An estimated 33 million diagnostic nuclear medicine examinations performed annually worldwide.

Biological effects of ionizing radiation

Death

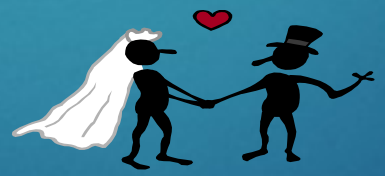
Cancer

Skin Burns

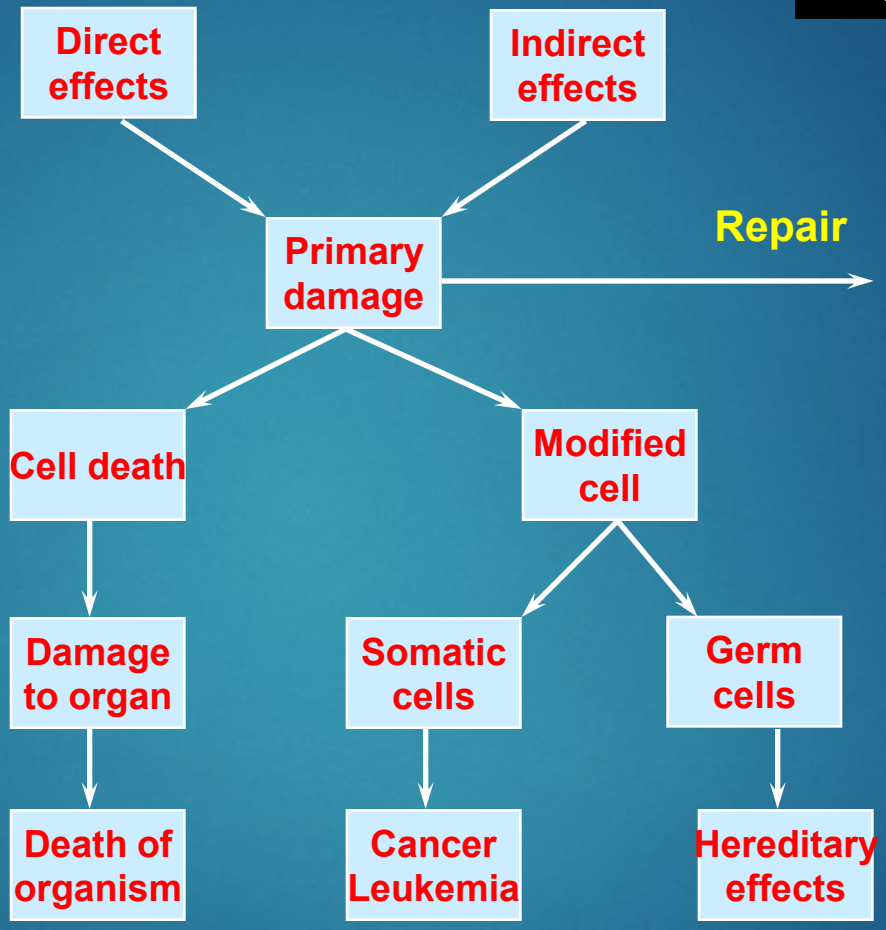
Cataract

Infertility

Genetic effects



Biological effects of ionizing radiation



Physical Quantities for Measurement of Radiation Exposures

Exposure

- Charge produced in unit mass of air from ionization by gamma and x-rays.
  - SI Unit is Columb/kg; special unit Roentgen (R)

Absorbed Dose

- Energy deposited by any form of ionizing radiation in a unit mass of material.
- Unit Joule/kg or gray (Gy) and 1 Gy = 100 rads

Equivalent Dose

- Accounts for the hazard potential of different types of radiation through a factor called Radiation Weighting Factor (w_R) Unit is sievert (Sv) $H_T\ (Sv) = \sum w_R D_{T,R,}$

Effective Dose

- Accounts for the different types of tissues and their sensitivity. Takes into account the tissue weightage factor..a measure of stochastic risk factor
- Unit is Sv; $E\ (Sv) = \sum w_T H_T = \sum w_T \sum w_R D_{T,R}$

Deterministic Effects for Whole body Exposure (Acute)

Dose Range	Immediate Effect
Less than 0.1 Gy	No detectable effect
Above 0.1 Gy	Chromosome aberrations detectable
Above 0.5 Gy	Transient reduction in WBC count
Above 1 Gy	Nausea, vomiting, diarrhea (NVD)
3 – 5 Gy	Lethal Dose (LD50/60) (lethal in 60 days to 50% of exposed population)
5 – 10 Gy	Increase in severity of above effects Almost 100% death (at higher dose)

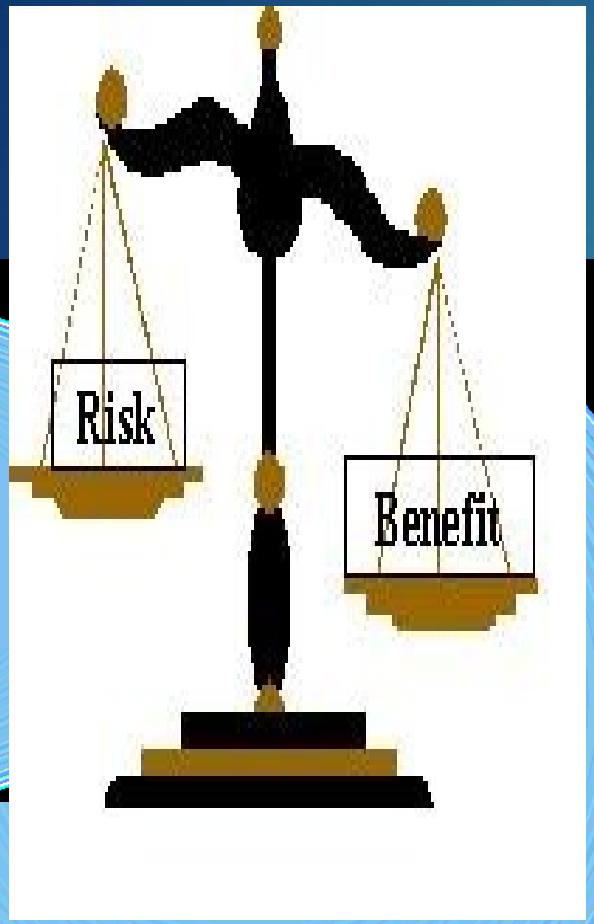
Typical Doses in X-ray Procedures

Procedure	Mean Effective Dose (mSv) to patient	Typical Organ doses (mGy)
CT Abdomen & pelvis	13.6	10-40 (stomach) 27 (bone surface) 88.5 (breast dose in Cardiac CT)
CT Chest	7.9	9-20 (Lung)
CT Head	1.8	60 mGy (head) ACR AAPM reference value)
Radiography	0.02 -1	0.11 (lung in chest X-ray)* 7.8 mGy (Bone surface in Lumbar spine X-ray)
Interventional Radiology	10-70	80-758 (Interventional CT [1]) 104-71600 (mean 2Gy for TIPS Creation[2])
Fluoroscopy	1-20	65 mGy/min (GI fluoro) ACR AAPM reference value
Dental Radiography	0.001-0.03	0.06 (Thyroid in Intra Oral) 0.15 (in Bitewing)

Radiation Protection Objective

- To prevent deterministic effects, e.g. skin burns, hair epilation, radiation sickness
- To reduce the probability of stochastic risk at an acceptable level, e.g. cancer, genetic effects

Principles of Radiation Protection



- **Justification**- whether benefit of use of radiation outweighs the risk – ***careful referral of x-ray examination and is it necessary ??.***
- **Optimization-** If exposure justified, then keep it as low as reasonably achievable (ALARA)
- **Dose Limits-** exposures should be within the prescribed dose limits

Atomic Energy Regulatory Board (AERB)

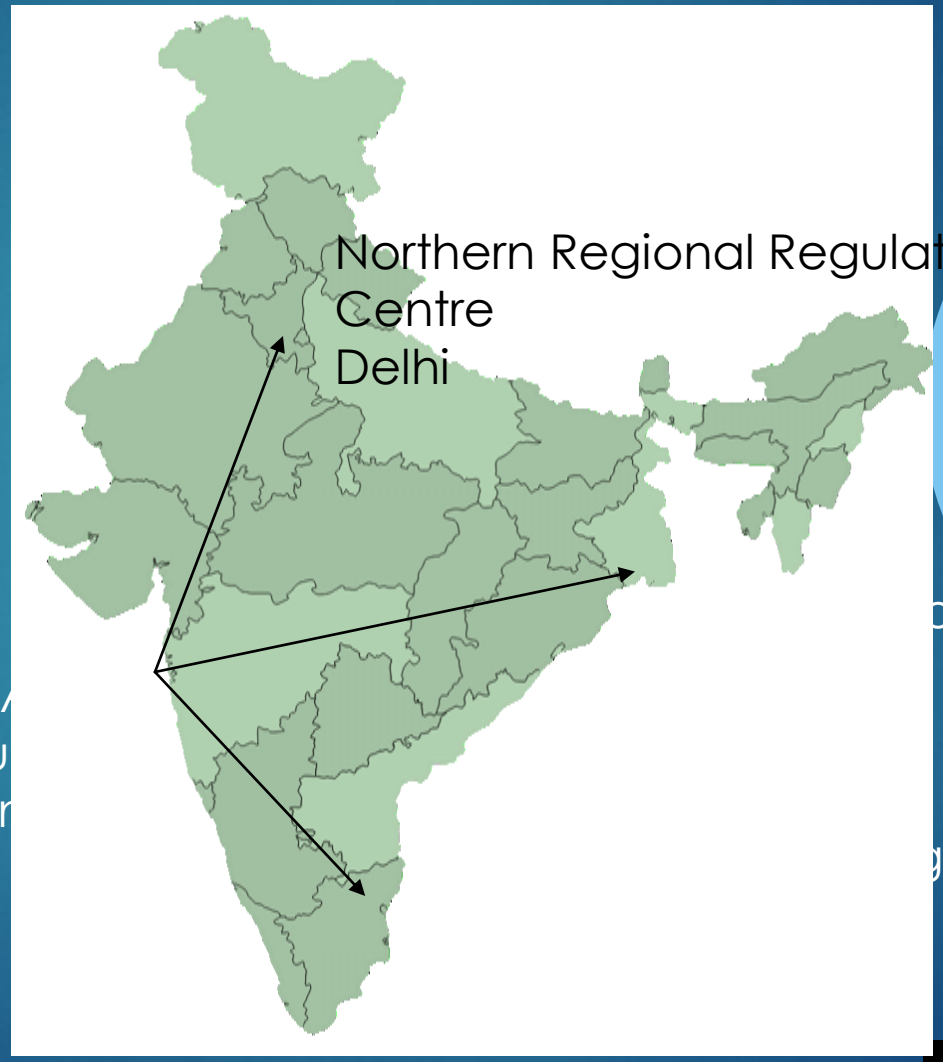
- *The National Regulatory Authority for radiation protection*
- AERB constituted in 1983.
- The *mission* of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health and the environment.
- *Chairman, AERB* is the Competent Authority for radiation protection in India.

AERB….

"Licence in accordance with Atomic Energy (Radiation Protection)Rules, 2004 from AERB is mandatory requirement for the procurement and use of radiation sources in India".

AERB, Anushaktinagar, Mumbai

Regional Regulatory Centers (RRC) of AERB



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Regulatory Framework

System of Regulatory Control	
Issued by Central Government Act [Atomic Energy Act, 1962] Rules [Atomic Energy (Radiation Protection) Rules, 2004] Notifications	**Published by AERB** Safety Codes Safety Standards Safety Guides Safety Manuals

AERB Safety Codes on Medical Applications

Radiotherapy: AERB safety code AERB/RF-SC/MED-1 (rev.1), 2011 on

" Radiation sources, Equipments and Installations"

Nuclear Medicine: AERB safety code AERB/RF-SC/MED-2 (rev.2), 2011

on " Nuclear Medicine facilities"

Diagnostic Radiology: AERB safety code AERB/SC/MED-3 (rev.2), 2016

on "medical diagnostic x-ray equipment and installation"

e-Governance of AERB (e-LORA) [e-Licensing Of Radiation Applications]

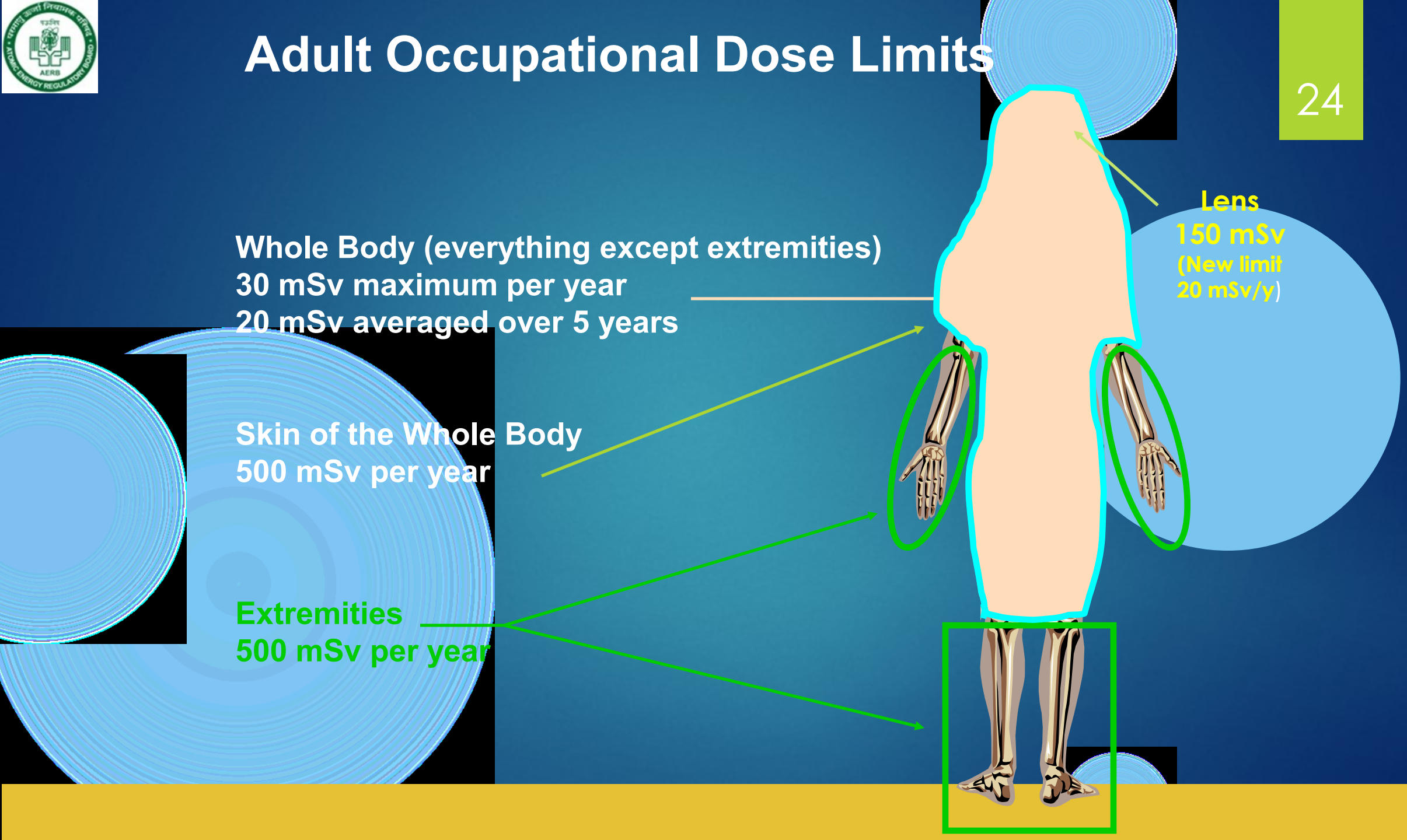
- Objectives of e-LORA
  - Online registration of Institutions and radiation professionals
  - Electronic submission of applications for regulatory clearances
  - Online tracking of submitted applications
  - e-Approvals

Adult Occupational Dose Limits

Whole Body (everything except extremities)
30 mSv maximum per year
20 mSv averaged over 5 years

Skin of the Whole Body
500 mSv per year

Extremities
500 mSv per year

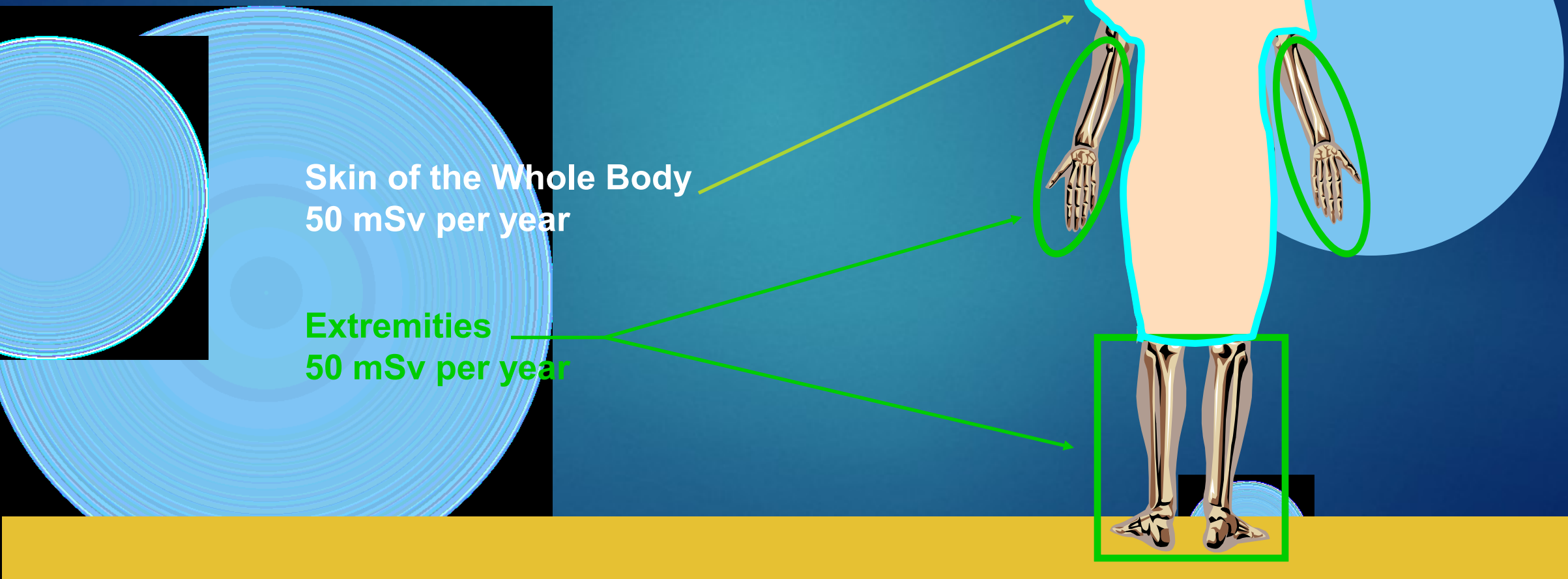


Public Dose Limits

Whole Body (everything except extremities)
1 mSv per year

Skin of the Whole Body
50 mSv per year

Extremities
50 mSv per year



Reporting of suspected occupational excessive exposure (EE)

- If in a reporting period, the dose received exceeds 10 mSv, the same needs to be reported to AERB and investigation is required.
- Challenge to AERB for minimising and prevention of EE cases in Diagnostic Radiology ??

Radiation Protection of Patient during Radiological Procedures

Issues in Radiation Protection of Patients in Radiotherapy

- **Higher patient load per machine (**which may lead to frequency of failure of components of the machine is higher which requires frequent performance test/QA)
- **Implementation of comprehensive quality audit program**
- **Inadequate Infrastructure for Calibration**
- **Lack of training program on advanced techniques** (e.g. IMRT,SRS/SRT, VMAT, Proton Therapy (upcoming)
- **Non-reporting of radiation incidences (**Reporting of radiation incidences are one of the most important factor for taking remedial action to avoid in future)

Issues in Radiation Protection of Patients in Nuclear Medicine

- Equipment linked manpower in Nuclear Medicine Facility
- Development of guidelines for handling and use of newly introduced radio-pharmaceuticals
- Estimation of radiation dose to the critical organ of the patients undergoing Diagnostic and Therapeutic procedures
- Harmonisation of various training programme conducted for Nuclear Medicine Technologists
- Incorporation of Radiation Safety Module in the course recognised by Medical Council of India
- Development of Diagnostic Reference Levels (DRLs) / Dose Constraints for NM procedures.

Issues in Radiation Protection of Patients in Diagnostic Radiology

- In hybrid imaging, with combined dose from radiopharmaceuticals plus the CT scan reaching an effective dose of 10 mSv or more for each examination.
- Patient dose recording and monitoring system in hospitals.
- Every referral for a radiologic examination should be fully justified by medical practitioner. Patient protection and safety of operating persons needs to be optimised during radiological procedures.
- Referring medical practitioner should have access to reports on all previous radiological procedures a patient has undergone. The report should indicate the dose received by patient.
- Need of special campaign for spreading awareness on radiation hazards and preventive actions among the public and radiological medical practitioners.

- **"SMART" Message for radiation protection in radiology**

Shielding is appropriate?
Marking of the film, ID etc. are appropriate?
Area collimation is appropriate?
Restriction on motion appropriate?
Technical setting is appropriate?

Reporting of excessive exposure to the patient undergoing Interventional Radiology Procedure leading to severe skin impairment – First case reported to AERB

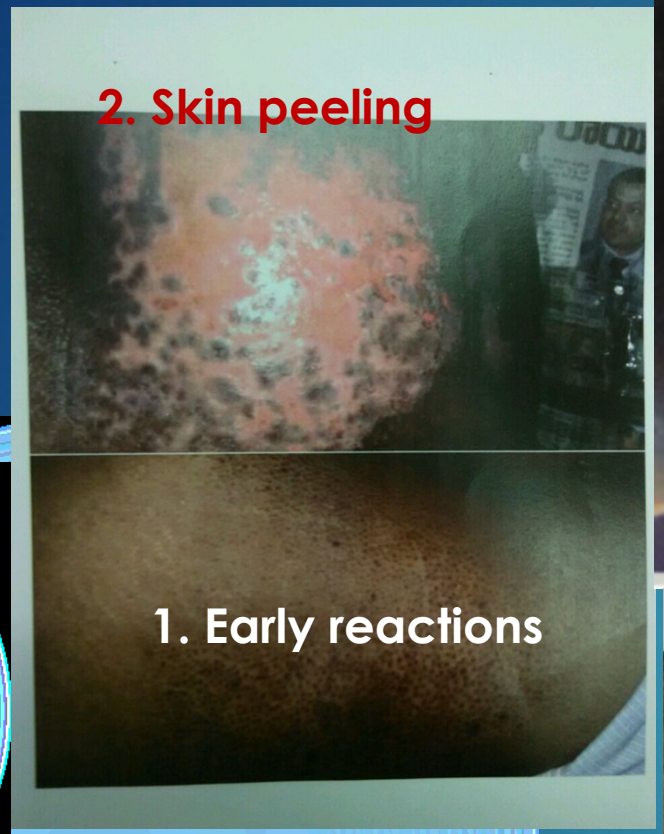
Reported case of radiation skin burns..

- Case of skin burn after undergoing IR procedure Reported in August 2016
- AERB received complaint regarding severe skin reactions to the patient, who had undergone radio-embolization (Interventional procedure for treatment of Pelvic AV malformation) in November 2015
- AERB carried out inspection for investigation on 30-31/08/2016
- Patient is still undergoing reconstructive surgery for the injuries

Reported case of radiation skin burns..

- Some Observations during Investigations
  - Patient Dose display and recording in the IR unit was not enabled – subsequently implemented after the reported case
  - Patient dose records not retrievable??
  - Doctors operating IR equipment did not have adequate knowledge on radiation safety and relevant safety features of the equipment
  - Training on radiation safety aspects and use of inbuilt safety features of the unit ?? Medical professionals had no idea on these aspects

A PREVENTABLE INJURY ?? There may be more?



There is a Need To Assume Collective Responsibility To Address Patient Safety In Diagnostic Radiology

Initiatives by AERB ....

- Efforts in brining more effectiveness in regulatory requirements for ensuring patient protection against ionising radiation.
- Accredited several QA agencies for providing QA services to x-ray facilities.
- Formulated guidelines for necessary periodic QA as per NEMA protocol to be performed for NM imaging devices.
- Standard QA protocol has been established for all equipment in radiotherapy.
- Recognized the National Audit Programme conducted by BARC for dose measuring instruments for dose measuring instruments.

Initiatives by AERB ....

- Accredited calibration laboratories for radiation survey instruments and contamination monitors.
- Recognized several medical physics and NM/RT professional courses conducted by various Institution / Universities.
- Initiatives for establishment of State DRS/RSA for x-ray facilities
- Awareness campaign by - Advertisement on print media, public information brochure, press releases, interviews, awareness programs, discussions with stakeholders, participation in CMEs and Conferences of medical professions associations/societies.
- Broadcasting of radio jingle….

Radio jingle of AERB developed by DAVP – To be broadcasted in major cities.

- AERB Jingle Option-1.mp3

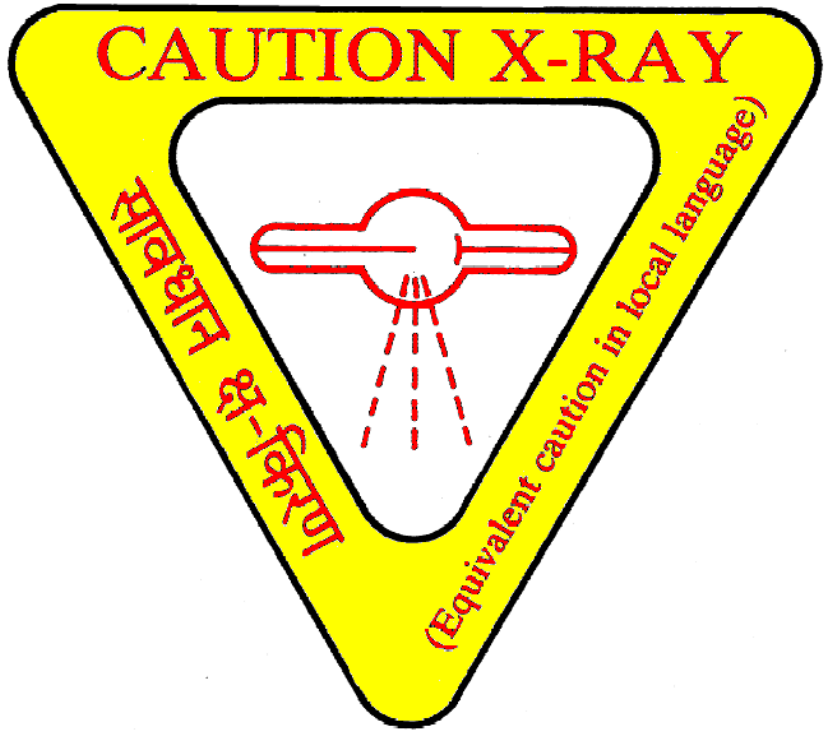
Conclusion

- Justification and optimisation of patient exposure during any radiological medical procedures is very essential and can be achieved by joint efforts of medical radiological practitioner and the supporting staff.

Unnecessary…casual.. referral to X-ray examination should be avoided by medical practitioners

- Overall occupational doses in medical applications of radiation are found to be much below the prescribed annual effective dose limits.
- However, the concern is that number of excessive exposure incidents to workers in the monitoring period are being reported in medical practices such as diagnostic radiology and nuclear medicine.
- The Safety Culture need to be established in the institution and further maintained all the times to ensure that dose constraints are not exceeded and importantly PMS badges are properly used.
- Awareness about radiation hazards and adherence with medical ethic would play crucial role in ensuring optimised and adequate radiation protection.

THANK YOU



RADIATION WARNING SYMBOL
for X-RAY EQUIPMENT

For further information : please visit www.aerb.gov.in