RADIOLOGY
TEAM 435

Contrast Media & Safety in Radiology

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Objectives:

1. Recognize, and evaluate essential information on the biologic effects of ionizing radiation and radiation safety to ensure the safe use of x-rays in diagnostic imaging.
2. Know radiation quantities and units, regulatory and advisory limit for human exposure to radiation.
3. Know equipment for radiation protection and measurement.
4. Understand the fundamental principles of MRI safety
5. Know about contrast agents reactions and safety.
6. Understand how to prepare patients for radiological studies.

Resources:

- 435 Slides
- 434 Team
- 435 Notes

Done by:

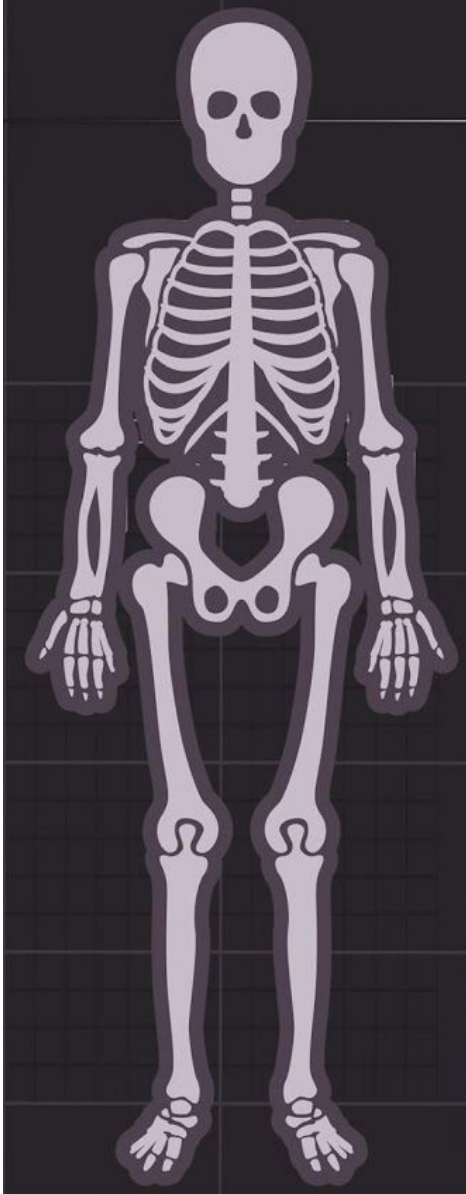
- Torki Alnasser
- Abdulnasser alwabel

Team Leader:

- Mohammed Alsahil

revised by:

- Ahmed Al Yahya



Introduction

- **Major Sources of Risk in Radiology:**
  1. Radiation hazard.
  2. Radioactive materials hazard.
  3. Magnetic field hazard.
  4. Contrast agents hazard.

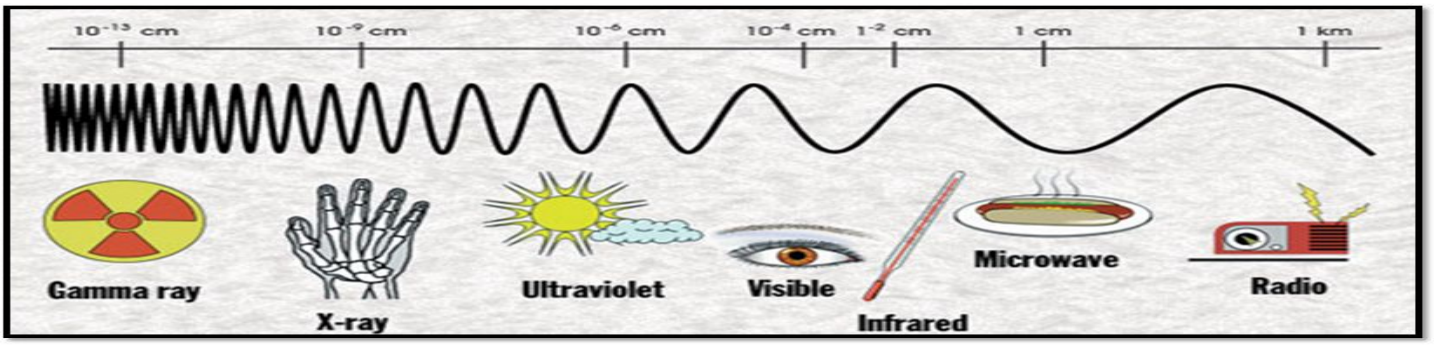
- **What is Radiation?**

radiation is an energy emitted from a substance, subdivided into:

- Non-ionizing (non hazard): Microwave oven, Television, Radiowaves, MRI , Ultrasound .
- Ionizing (hazard) : alpha particles (α), beta (β), gamma (γ) and X-rays.

*Ionizing radiation can be carcinogenic and, to the fetus, mutagenic or even lethal.

- **Radiation spectrum**



- **research pioneers**

Roentgen:Discoverer of X-rays 1895
Becquerel:Discoverer of Radioactivity 1896
Rutherford: Discoverer Alpha and Beta rays 1897
The Curies:Discoverers of Radium and Polonium 1900-1908

- **What is an X -ray ?**

X-rays are very short wavelength electromagnetic radiation.
The shorter the wavelength and higher the frequency , the greater the energy and the greater the ability to penetrate matter.

- **Goals of radiation safety:**

- To eliminate deterministic **(acute)** effects.
- To reduce incidence of stochastic **(Chronic)** effects.

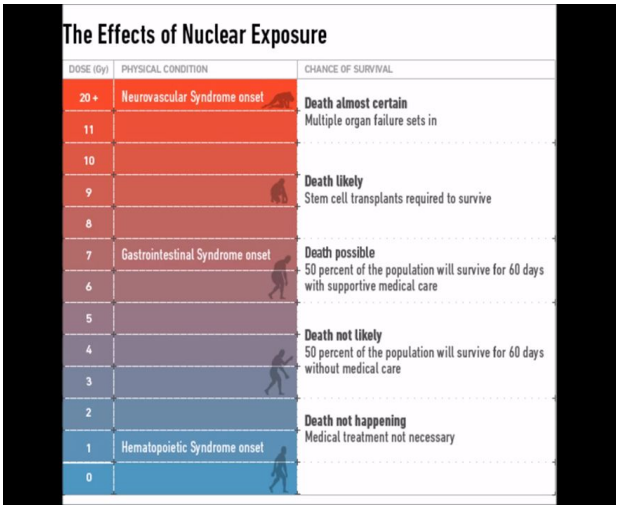
Deterministic Effects

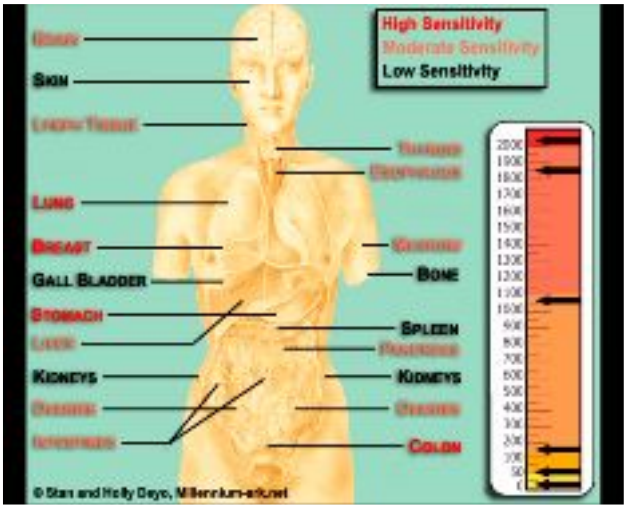
	Acute/deterministic effects	Chronic/Stochastic effects
Definition	Acute radiation symptoms are caused by high levels of radiation usually over a short period of time.	• Also referred to as (Probabilistic), probability of occurrence depends on absorbed dose. • Chronic radiation symptoms are caused by low-level radiation over a long period of time
Characteristics	• They cannot be predicted with certainty • severity o f damage increases with increasing dose above that threshold. • All machines are made so that the radiation does not exceed the threshold, but repeated exposure to radiation can lead to deterministic effects.	• The effect may (potentially) occur following any amount of exposure, there is no threshold. • Even the smallest quantity of Ionizing Radiation exposure can be said to have a finite probability of causing an effect. • Severity of the effect is not dose related.
Examples	Cataract, Bone marrow failure, Lung Fibrosis, Infertility, hair loss, Cataract formation, lowering the WBC count, Skin reddening (erythema) .	1. Carcinogenic effect 2. Genetic effect

- **Threshold for deterministic effects:**

organ	Effects	One single absorption (Gy)	Prolong absorption (Gy-year)
Testes	permanent infertility	3.5-6	2
Ovaries	permanent infertility	2.5-6	>0.2
Eye lens	milky of lens cataract	0.5-2 5	>0.1 >0.15
Bone Marrow	Blood forming deficiency	0.5	>0.4

- Gray is unit of exposure of radiation.
- One chest X-ray= 0.15 mGy.
- To reach the hazardous level of 2 Gray you need 10000 chest x ray, 100 abdominal CT or 30 mins to 1 hr fluoroscopy exposure.
- **1CT=** 1000 X-rays
- Fluoroscopy has the highest and X-ray has the lowest





quantity	unit	SI unit	relation between unit
absorbed dose	Rad	Gray (Gy)	1Gy = 100 rad 100 mGy = 10 rad 10 mGy = 1 rad 1 mGy = 100 mrad
equivalent dose	Rem	Sievert (Sv)	1Sv = 100 rem 100 mSv = 10 rem 10 mSv = 1 rem 1 mSv =100 mrem

Typical Radiation Detectors :	
- Film packet	- Thermoluminescent Dosimeter **(TLD)**
- Ionization chamber	- Geiger-Müller **(GM)** Detector
- Scintillation Detector	

Radiation Exposure Levels & Effects	
0.62 rem/y	average annual radiation exposure.
2 rem/y	international radiation exposure limit.
25 rem/y	measureable blood changes.
100 rem	onset of radiation sickness.
200 rem	radiation sickness with worse symptoms in less time
400 rem	approximately the lethal dose for 50% of the population in 30 days
1,000 rem	death probable within about 2weeks, effects on the gastrointestinal tract
5,000 rem	death probable within 1-2 days, effects on the central nervous system.

General Methods of Protection

- **Minimize exposure time.**
- **Maximize distance** from the X-ray source (Exposure varies inversely with the square of the distance from the X-ray tube)
- **Use shielding:**
  - Operators view the target through a leaded glass screen.
  - Wear lead aprons (in the picture below). Almost any material can act as a shield from gamma or X-rays if used in sufficient amounts. Standard 0.5mm lead apron Protect you from 95% from radiation exposure.

- **ALARA Rule:** As low as reasonably achievable:
  -Reduce number of exams.
  -Reduce time of exams.
  -Radiation Hazard symbol displayed at places where radioactive materials are used and stored.
  -Use alternative (US or MRI).

Radioactive Material Hazards

- **Radioactivity:**

- Radioactive decay is the process in which an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic waves.
- An unstable nucleus releases energy to become more stable.

Radioactivity Sources	
Naturally Occurring Sources	- Radon from the decay of Uranium and Thorium. - Potassium -40 – found in minerals and in plants. - Carbon 14 – Found in Plants and Animal tissue.
Manmade Sources:	- Medical use of Radioactive Isotopes. - Certain Consumer products –(eg Smoke detectors). - Fallout from nuclear testing. - Emissions from Nuclear Power plants.

- **Radioisotopes:**

- Isotopes of an atom that are radioactive are called radioisotopes.
- These atoms are radioactive because they have too much energy to be stable; they will release energy until they become stable.
- This is called radioactive decay.
- **Medical uses:**

Radioactive isotopes are introduced into the body and can be distinguishable by their radiation from the atoms already present. This permits the relatively simple acquisition of information about the dynamics of processes of uptake, incorporation, exchange, secretion, etc.

- **radioactive decay:**

In the process of radioactive decay. An atom actually changes from one element to another by changing its number of protons.

The **half-life** of radioactive substances is the amount of time they require to lose *one half* of their radioactivity and transform into another element.

- **Radiopharmaceuticals:**

The most widely used radioisotope is Technetium (Tc), with a half-life of six hours. The activity in the organ can then be studied either as a two dimensional picture or, with a special technique called tomography, as a three dimensional picture (SPECT, PET).

- **Handling Radiopharmaceuticals:**

- No radioactive substances should be handled with bare hands. Alpha and beta emitters can be handled using thick gloves.
- Radioactive materials must be stored in thick lead containers.
- Reactor and laboratories dealing with radioactive materials must be surrounded with thick concrete lined with lead.
- People working with radioactive isotopes must wear protective clothing, which is left in the laboratory.
- The workers must be checked regularly with dosimeters, and appropriate measures should be taken in cases of overdose.
- Radioactive waste must be sealed and buried deep in the ground.

- **Spill Response:**

- On Skin —> flush completely.
- On Clothing —> remove them.
- If Injury —> administer first aid.
- Radioactive Gas Release —> vacate area, shut off fans, post warning.
- Monitor all the people and define the area of contamination.

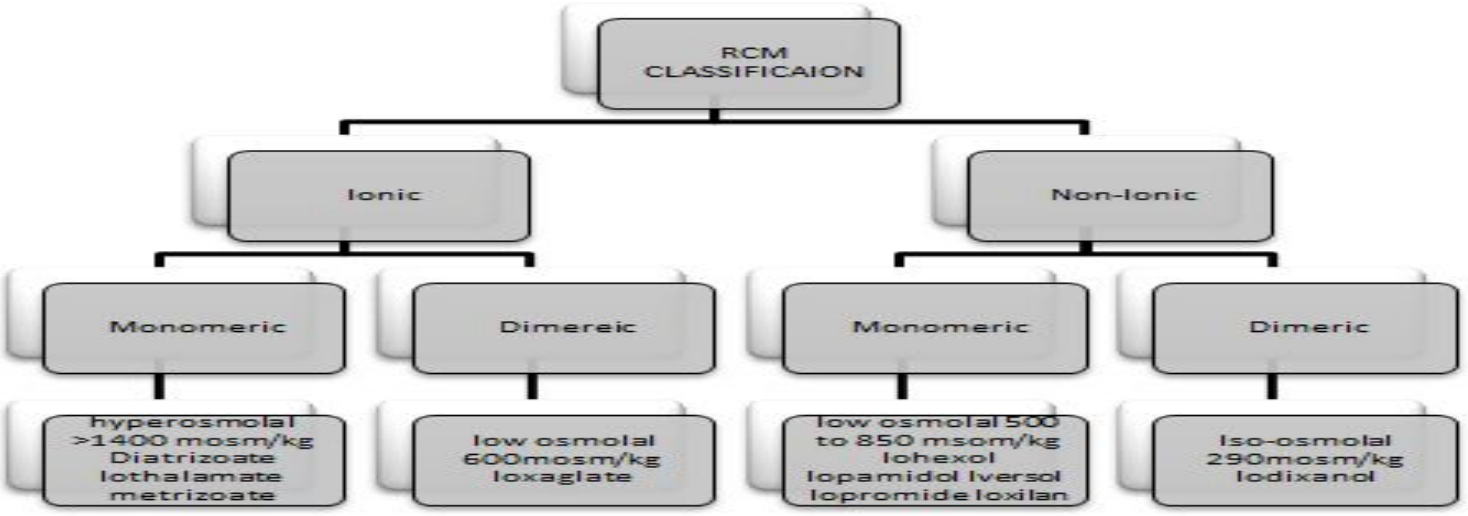
MRI Hazard

- There is no dangerous radiation in MRI instead it uses very high magnetic field up to 3Tesla (1 Tesla = 20000 times earth gravity). This strong magnetic field produces a powerful attractive force and torque which the magnet exerts on ferromagnetic objects, this is called missile effect. The missile effect can pose a significant risk to anyone in the path of the projectile, and cause significant damage to the scanner. The effect is clearly greater for high field systems.
- To guard against accidents from metallic projectiles, the "5 gauss line" should be clearly demarcated and the area with that line kept free of ferromagnetic objects.
- MRI contraindications: Patients with ferromagnetic surgical clips (Aneurysm clips), Pacemaker, implanted cardiac defibrillator, implants containing ferromagnetic or paramagnetic components. And people who have suffered from shrapnel or steel fragment injuries, especially to the eyes.
- Access to the imaging area should be limited, and signs should be displayed to warn persons with cardiac pacemaker or neuro-stimulators not to enter the area.
- Credit cards and watches with mechanical parts should be left outside the imaging area to prevent magnetic tape erasure and watch malfunction.

Contrast Agents

- Compounds used to improve the visibility of internal bodily structures in an image.
- Since their introduction in the 1950s, organic radiographic iodinated contrast media (ICM) have been among the most commonly prescribed drugs in the history of modern medicine.
- These contrast agents attenuate x-rays more than body soft tissues due to their high atomic weight.
- Millions of intravascular contrast media examinations are performed each year.
- Iodinated contrast media generally have a good safety record.
- Adverse effects from the intravascular administration of ICM are generally mild and self-limited;Reactions that occur from the extravascular use of ICM are rare. Nevertheless, severe or life-threatening reactions can occur with either route of administration.

contrast type	negative	positive
Organs become	radiolucent	radiopaque
Atomic weight	Low atomic	High atomic
Color on film	Black	White
Examples	air CO2	Iodinated contrast agent. Barium sulfate
Uses	**inflate a structure:** distinguish colon from other structures	Urogenital Studies Vascular Studies



- The toxicity of contrast agents decreases as osmolality approaches that of serum. This has been accomplished by developing non-ionizing compounds and then combining two monomers to form a dimer.
- Currently used iodinated agents are cleared almost completely by glomerular filtration.
- Circulatory half life is 1–2 hours, assuming normal renal function.

- **Effect of ionic vs non ionic contrast media**

ionic	non ionic
dissociate into separate ions when injected	does not dissociate
creates hypertonic condition	remains near isotonic
increase in blood osmolality	no significant increase
less money	more money
more reaction	less reaction

Methods of administration of contrast material	
INGESTED	ORAL: Barium sulfate suspension
RETROGRADE	AGAINST NORMAL FLOW: Barium Enema
INTRATHECAL	Spinal canal
INTRAVENOUS	Injecting into bloodstream (anything other than oral)

Reaction classification	
Immediate reactions: occur within the department (within one hour). **Delayed** reactions: occur between the time the patients left the department and up to seven days later. It is important for anyone administering intravenous contrast media to be aware of delayed reactions. The most common reactions include: a cutaneous exanthema, pruritus without urticaria, nausea, vomiting, drowsiness,headache ,flu like symptoms delayed arm pain , salivary gland swelling, and Steven Johnson syndrome also The American College of Radiology has divided adverse reactions severity to contrast agents **into the following categories:**	
Mild Reaction (5%)	Signs and symptoms appear self-limited without evidence of progression, Nausea, vomiting, warmth, headache, dizziness, shaking, altered taste, itching, flushing, chills, sweats, rash, nasal stuffiness, swelling: eyes, face and anxiety. **Treatment:** Observation and reassurance. Usually no intervention or medication is required; however, these reactions may progress into a more severe category.
Moderate Reaction (1%)	Reactions which require treatment but are not immediately life-threatening, Tachycardia/ bradycardia, hypertension, pronounced cutaneous reaction, hypotension, dyspnea, pulmonary edema, bronchospasm, wheezing and laryngeal edema. **Treatment:** Prompt treatment with close observation.
Severe Reaction (0.05%)	Life-threatening with more severe signs or symptoms including, Laryngeal edema (severe), profound hypotension, convulsion, unresponsiveness and cardiopulmonary arrest. **Treatment:** Immediate treatment, antiemetic drugs. Usually requires hospitalization.

- **EXTRAVASATION:**

- Contrast material has seeped outside of vessel. To treat Apply a **WARM** Compress 1st 24 hours and cool compress for swelling.

Reaction Medications	
- Aggressive fluids.	- Lasix
- Dopamine	- Mannitol

Contraindications for Contrast	
Renal Failure (Check BUN & Creatinine)	Diabetes
Anuria (no urine production)	Multiple Myeloma
Asthma (possible allergies)	Pregnancy (risk of fetal Thyroid toxicity).
Hx of Contrast Allergy / Reactions	Allergic Reaction, Pre – medication is available.
get a hx of medications taken glucophage must be stopped 48 hrs before contrast injection	

MRI Contrast Agents

- The Contrast used in MRI is based on paramagnetic ions e.g. Gadolinium.
- By themselves, these ions are highly toxic so they bind up in large molecules eg. DTPA.
- Provides a greater contrast between normal and abnormal tissues.
- With impaired kidney function, gadolinium could lead to a serious and potentially fatal disorder called **Nephrogenic Systemic Fibrosis**. (NSF)