Radiation

By

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F. Radiation

A.Ionizing radiation

1. Electromagnetic radiation
    - Gamma Rays (Ý)
    - X-Rays
2. Particulate Radiations

- Alpha (α-particles)
- Beta (β-particles)
- Electrons, protons, neutrons, Negative Pi-mesons, Heavy charged ions and other atomic particles varying in mass and charge.

B. Non ionizing Radiation

1. LASER (Light Amplification by Stimulated Emission of Radiation)
2. Ultraviolet Radiation
3. Visible light
4. Infrared
5. Microwaves and Radiofrequency
6. Ultrasound
7. Radio waves
8. Video Display Terminals (VDT)

Radiation (def)
Radiation is the emission and propagation of energy=the emitted energy itself
1.Electromagnetic Radiation
Are listed in order of increasing wavelength and decreasing frequency.

A.Gamma Rays
B.X-Rays or Roentgen (roentgen discover X-Rays in (1895)
Which process an mass or charge and which are characterized by extremely short wave length and high frequency.
When x-ray (photon) has more than 15 ev (electron volts) of energy, it is able to ionize an atom and is thus referred to ionizing radiation.
The energy of photon is inversely proportional to the wave length.
Photon =smallest quantity of electromagnetic radiations, an x-ray, Gamma ray and other.

2. particulate radiations.

a. Alpha (α-particles).

b. Beta (β-particles).

Particles from radio-active decay.

c. Electrons, protons, neutrons, negative pi-mesons, heavy charged ions and other atomic particles varying in mass and charge.

(Mesons= subatomic, short-lived particles of mass less than that of a proton but more but more than of an electronic, carrying either a positive or negative charge called also mesotron).

Both types of ionization radiation differ from other forms of radiant energy in being able to disrupt the atoms and molecules on which they impinge, othereby producing ions, free radicals, and, in turn biochemical lesions.

An ionizing radiation penetrates matter, it gives up its energy by colliding with atoms and molecules in its path. Such collisions are clustered so closely together along the path of an alpha particle that the particle typically has only enough energy to transverse a few cells, whereas the collisions are separated so far apart along the path of an x-ray that the radiation can transverse the entire body.
The average rate at which energy is deposited per unit length of path, i.e., the linear energy transfer (LET) of the radiation, is customarily expressed in kilo electron volts per micrometer (Kev／μm).
In general, the chigger the LET of the radiation, the more likely it is to deposit enough in a critical site within the cell, e.g., a deoxyribonucleic acid (DNA) molecule or a chromosome, to cause an irreparable molecular lesion. Alpha particles and other high-LET radiations are typically more potent, therefore, than low-LET radiations such as X-rays.

- The electromagnetic Radiation is the most familiar energy and they behave as "waves" e.g., radio frequency waves.
- The electromagnetic Radiation are also classified according to its biological effects on matter.

a. Ionizing Radiation.
b. Non-Ionizing Radiation.

- The electromagnetic Radiation used in radiology are also classified in form of its origin:
  - a. Natural radiation.
  - b. Artificial radiation.

The sources of Radiation in the U.K:

a. Natural Background (85%).
- Cosmic Rays 10%.
- From food and drinks 11.5%.
- Gamma Rays from the ground and buildings 14%.
- Radon-gas from ground 50%.

(Radon : colorless odorless naturally occurring radioactive gas)

b. Artificial (Man-made) Radiation 15%
Radiotherapy 14% medical (radio-diagnosis, nuclear medicine)
Nuclear discharge and products, fallout and occupational 1%.

Radiological units.

The international system (SI) of units has come into increasingly wide use in place of the centimeter-gram-second (cgs) system. The SI unit for expressing the dose of radiation that is absorbed in tissue is the gray (Gy) :1GY =1 joule per kilogram of tissue.
Different units are used define exposure, absorption, dose equivalence and radioactivity.

1. Roentgen ®.

The unit of measurement of X-ray and Gamma rays radiation exposure, required librating 2.5×10 coulombs of charge per Kg of air which

2. Gray (GY).

the unit of radiation absorbed does in matter.

1 GY=1Joule \ Kg of material.

1 GY=100 Rad (Roetgen absorbed dose).

1 C\ centigray (CGY)=1 Rad.

3. Sievert (St).

The units of absorbed does, which takes into account the relative biological effect of the varying types of ionizing radiation.

1 Sv =100 rem (Rem Equivalent Man)

4. curie (CI), Beequarel (Bq)

The unit of radioactivity. It is a unit of the quantity of radioactive material and not the radiation emitted by the material. One Curie is the quantity of material in watch 3.7 10 atoms disintegrade every second.

Some uses of Electromagnetic Radiation as a whole.

A. Ionizing Radiation.

1. Medical diagnosis and treatment.
2. Nuclear power.
3. Industrial radiography and fluoroscopy.
4. Sterilization of medical equipments.
5. Agriculture research, security and others.

B. Non-ionizing Radiation

Optical sources

1. Lighting
2. Heating
3. Measurement
4. Sterilization

Electromagnetic fields

1. TV and radio broadcasting
2. Personal telecommunication

X-Rays and their properties

X-Rays are invisible electromagnetic waves similar in natural to e.g. Radio, heat, and light waves but with the characteristic of having very Short wavelengths (10 to 10^{-10} m wavelength) and very high frequency and because of their short wavelength, they have the ability to penetrate matter.

Their properties are:

1. they are rapidly fluctuating electric and magnetic fields.
2. they are generated by bombarding a metal target with high energy electrons.
3. they travel in free space in straight lines with the speed of light ($3x10^{10}$/sec.)=300.000km/sec.
4. in free space they obey the "inverse square law" as their intensity decreases proportionally to square distances.
5. as they pass through matter, their intensity reduced as follows:

Attention= Absorption +Scattering

The denser the mater, the greater the amount of absorption.

6. X-Rays absorbed by matter are proportional :

Atomic Number/Density and thickness of matter through which they pass.

7. Scattering : As X-Rays pass through matter some of the rays become deflected altering their direction producing new softer radiation within the substances, these called Scatter Radiation and they have damaging effects radiologically.
8. X-Rays can penetrate matter and this is a useful and important property which applied in diagnostic Radiology.
9. X-Rays produce photographic effects as that produced by visible light.
1o. X-Rays cause ionization of substances through which they pass and therefore the X-Rays are parts of the ionization radiation.
11. Fluorescence : certain substance e.g. calcium tungstate and zinc sulfide can transform the visible X-Rays energy into visible light, which is used on fluoroscopy and intensifying screens.
12. The X-Rays radiation is of sufficiently high energy and short wavelength that the radiation behaves more as particles rather than waves, each particle called photon and carries energy.
13. Biological effects : This is the damaging effects due to ionization's property of the X-Rays and it is useful in the radiotherapy treating malignant tumors but these effects should be limited to a minimum in radio-diagnosis by appropriate measures.

Effects of Radiation at the cellular le level

1. Gene mutation
2. chromosome aberration
3. Cytotoxic effects
4. Effects on tissue and organs : skin, GIT, reproductive organs, lens of the eyes, blood forming tissues
5. The acute Radiation Syndrome
6. Carcinogenic effects
7. Leukemia
8. Cancer of the breast
9. Thyroid gland malignancy
10. Effects of pre-natal irradiation on growth and development

The biological effects of radiation

1. The biological effects of radiation can be due to various sources :
   a. Natural radiation sources
b. Medical radiation exposures
   c. Exposure to thermonuclear weapons

2. Various body tissue have different radiation sensitivity :
A. The most radiation sensitive tissue (high)
1. Haemopoitic stem cells (Erythroblasts)
   2. Lymphocytes
   3. Intestinal crypt cells
4. Epidermal cells
   5. Oogonia and spermatogonia

B. Relative sensitive cells (intermediate) :
1. Endothelial cells
2.Osteoblasts and fibroblasts series
3. Eye lenses
4. Spermatocytes and oocytes

C. Medium to low sensitivity (low)
1. Muscle cells
2. Nerve cells
3. Chondrocytes

3. Small irradiated volume of the body can tolerate a much larger absorbed dose in rads than large volume can.

4. The biological effects induced by radiation are classified :

A. Deterministic effects : is the clearly established relationship between the level of exposure and the resulting biological effects and occur at higher doses and have threshold below which they do not occur (cataract, erythema, haemopoietic ,changes and examples)

B. Stochastic effects which occur by chance and result in cancer and genetic changes ,and believed to be the major hazard of low doses radiation exposure experienced during radiological and nuclear imaging procedures.

5. The effects of radiation upon living tissue depend on the radiation source and system being irradiated, the quality, quantity of radiation exposure and the dose rate as well as the condition under which the dose is delivered.

Human responses to ionizing radiation

A. Early effects of radiation on human;

1. Acute radiation syndrome.

Can occur following total body exposure exceeding 1 Gy and a dose of about 2.5 Gy will lead to death in 50% within 60 days(LD 50/60).

a. The haemotopoitic syndrome : Result from damage to stem cells in bone marrow and lymphatic organs, usually occur above doses of 2 Gy, death occurs within 3 weeks as a result of infections and hemorrhage due to granulo and thrombocytopenia.

b. Gastro-intestinal syndrome : occurs when doses exceeds 7 Gy because of the loss of intestinal vascular barrier resulting in sepsis and death within 3 days.

c.The central nervous system syndrome : is characterized by immediate onset of severe neurological changes with convulsion and death within 2 days following severe exposures of over 10Gy.

2. local tissue damage:

a. Skin , approximately 1Gy is the threshold changes of erythema and epilation within few days

b.Gonads : at 2.5 Gy temporary and permanent sterility occurs respectively in both males and females.

c. The eyes react with cataract formation at 2 Gy or higer.

3. Hematological depressions ;

Affection of blood forming organs in form of depression of blood count mainly the WBC and platelets.

4. Cytogenetic damage ; damage to the cell chromosomes leading to genetic aberration by mutation.

B. Late effects or radiation on humans :

Are due to natural and artificial environmental radiation exposures including medical application

1. Leukemia
2. other malignant tumors : bone cancer , lung cancer, thyroid cancer , breast cancer , stomach cancer , liver cancer , bladder cancer , and other occurring after a latency period over 10years .
3. local tissue damage : following skin erythema ,epilation , infection ,ulceration .
4. life span shortening.
5. genetic effects.

C. Effect in fetal irradiation .

Radiation protection .

1. Any level of radiation , however small , can theoretically cause damage to living of cellular level and therefore , there is no threshold below which radiation can .

2. Alpha particles are among the most damaging due to their great mass and charge followed by beta particles (electron)and gamma rays.
3. all X-Rays and nuclear medicine examination should be clinically justified and the benefit to patient health should outweigh any possible harm.

The main parameter upon which protection from external radiation depends are :

1.Time

The total radiation exposure is directly proportional to the time exposed and therefore it is recommended to spend no more time than absolutely necessary near radiation source and also unnecessary X-Ray examinations should by avoided.

In radiology department every effort is made to keep radiation doses low and whenever possible to use U/S and MRI which involve no hazardous radiation .

2. Distance

The intensity of radiation source varies inverse as we square of the distance (inverse square law) and thus by increasing the distance from the source of radiation is reduced (keep distance) . never stand in the primary beam .

3.Shelding

Shelding is also a means of radiation protection by using protective devices whenever one is working in contact directly in contact with radiation e.g. lead apron ,lead gloves , stand behind lead glass barrier , lead eye glasses , lead sheet for neck (thyroid) lead sheets for covering the gonads particularly at age <30 years and special attention to pregnant women

4. Activity

Radiation hazard increases as activity increases , so one should avoid working in high levels of activity.


Thank you
very much