AL-Mustaqbal University College

Nuclear Medicine

for B.Sc. Students

By Lecturer

Sarah Jaleel Ahmad

Lecture One / Principles of Diagnostic radioisotopes

Vocabulary of the nuclear medicine curriculum

1. **What is nuclear medicine, basic atomic and nuclear physics**

   Physics of atom and nucleus (structure and theory) Classification of radiations

2. **Radioactivity and radioactive decay.**

   Neutron emission ,Neutron disintegration, Proton emission, Electron capture Decay radiation elements to be stable, transformation process, physical half-life, biological half-life Units of radioactivity

3. **Radiopharmaceuticals.**

   Types , uses,

4. **Radition detectors in nuclear medicine**

   Geiger-Muller detector, scintillation detector, soled detector, semi-conductor detector.

5. **Nuclear Image**

   Gamma camera, Rectilinear scanner, positron camera,

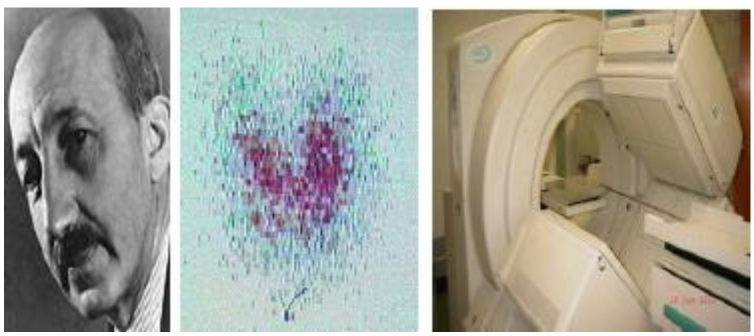
6. **Tomographic reconstruction in nuclear medicine (SPECT, PET)**

7. **Internal radiation dosimetry**

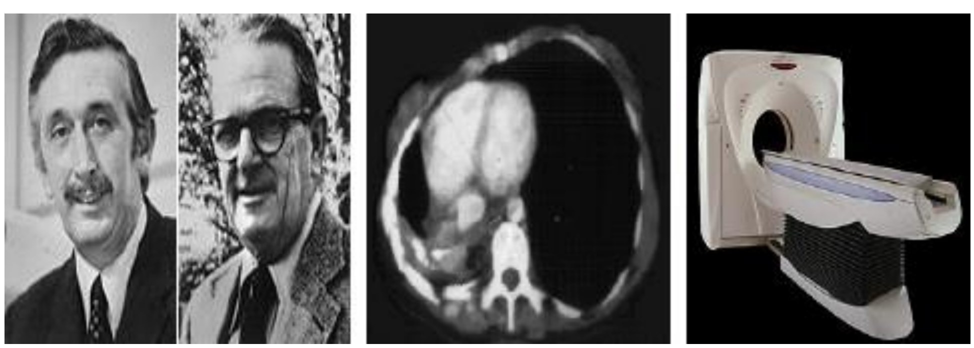
   Interaction of radiation with the biological tissue

8. **Radiation protection**

Discovey of X-rays
1901: Wilhelm Roentgen



Radiopharmaceuticals
1943: George de Hevesy



Development of X-ray CT
1979: Hounsfield & Cormack

A- Medical physics

The field medical physics overlaps the two very large fields of medicine and physics and its refer to two major areas:

1. The applications of physics to the function of the human body in health and disease (Physiology).
2. The applications of physics in the practice of medicine e.g: physics of the stethoscope, and the medical applications of lasers, ultrasound, radiation and so forth.

B- Biophysics

The field that should include medical physics as an important sub specially. Its primarily involved with the physics of large biomolecules, viruses, and so forth. It does approach medical physics in the areas of transport of material across cell membranes.

Physical medicine:

The branch of medicine that deals with the diagnosis and treatment of disease and injury by means of physical agents such as manipulation, massage, exercise, heat, and water.

Physical therapy:

Is the treatment of diseases or bodily weakness by physical means such as massage and gymnastics rather than by drugs.

The field of medical physics has several subdivisions:

1. Radiological physics: This involves the applications of physics to radiological problems includes the use of radiation in the diagnosis and treatment of diseases as well as the use of radionuclides in medicine (nuclear medicine).
2. Health physics: This involves radiation protection of patients, workers, and the general public and also includes radiation protection outside of hospital such as around nuclear plants and industry.

The word medical is sometimes replaced with the word clinical if the job is closely connected with patient problems in hospitals, i.e., clinical physics.

Radiation

Radiation is energy in the form of waves or streams of particles.

Type of Radiation

1- Alpha Radiation

Alpha is a heavy, very short-range particle and is actually an ejected helium nucleus. Some characteristics of alpha radiation are:

- Most alpha radiation is not able to penetrate human skin.
- Alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds.
- A thin-window Geiger-Mueller (GM) probe can detect the presence of alpha radiation.
- Instruments cannot detect alpha radiation through even a thin layer of water, dust, paper, or other material, because alpha radiation is not penetrating.
- Alpha radiation travels only a short distance (a few inches) in air, but is not an external hazard.
- Alpha radiation is not able to penetrate clothing.

Examples of some alpha emitters: radium, radon, uranium, thorium.

2- Beta Radiation

Beta radiation is a light, short-range particle and is actually an ejected electron. Some characteristics of beta radiation are:

- Beta radiation may travel several feet in air and is moderately penetrating.
- Beta radiation can penetrate human skin to the "germinal layer,"

- Beta-emitting contaminants may be harmful if deposited internally.
- Most beta emitters can be detected with a survey instrument and a thin-window GM probe (e.g., "pancake" type). Some beta emitters, however, produce very low-energy, poorly penetrating radiation that may be difficult or impossible to detect. Examples of these difficult-to-detect beta emitters are hydrogen-3 (tritium), carbon-14, and sulfur-35.
- Clothing provides some protection against beta radiation.

Examples of some pure beta emitters: strontium-90, carbon-14, tritium, and sulfur-35.

3- Gamma and X Radiation

Gamma radiation and x rays are highly penetrating electromagnetic radiation. Some characteristics of these radiations are:

- Gamma radiation or x rays are able to travel many feet in air and many inches in human tissue. They readily penetrate most materials and are sometimes called "penetrating" radiation.
- X rays are like gamma rays. X rays, too, are penetrating radiation. Sealed radioactive sources and machines that emit gamma radiation and x rays respectively constitute mainly an external hazard to humans.
- Gamma radiation and x rays are electromagnetic radiation like visible light, radiowaves, and ultraviolet light. These electromagnetic radiations differ only in the amount of energy
- Gamma radiation is easily detected by survey meters with a sodium iodide detector probe.
- Gamma radiation and/or characteristic x rays frequently accompany the emission of alpha and beta radiation during radioactive decay.

Examples of some gamma emitters: iodine-131, cesium-137, cobalt-60 and radium-226.

Classification of radiation

Radiation, the transport of energy by electromagnetic waves or atomic particles , can be classified into two main categories depending on its ability to ionize matter. The ionization potential of atoms, i.e. the minimum energy required to ionize an atom, ranges from a few electronvolts for 24.6 ev for helium which is in the group of noble gases. Ionization potentials for all other atoms are between the two extremes.

1-Non-ionizing radiation cannot ionize matter because its energy per quantum is below the ionization potential of atoms. Near ultraviolet radiation, visible light, infrared photons, microwaves and radio waves are examples of non-ionizing radiation.

2-Ionizing radiation can ionize matter either directly or indirectly because its quantum energy exceeds the ionization potential of atoms. X rays, γ rays, energetic neutrons, electrons, protons and heavier particles are examples of ionizing radiation.

Classification of ionizing radiation

Ionizing radiation is radiation that carries enough energy per quantum to remove an electron from an atom or a molecule, thus introducing a reactive and potentially damaging ion into the environment of the irradiated medium. Ionizing radiation can be categorized into two types: (i) directly ionizing radiation and (ii) indirectly ionizing radiation. Both directly and indirectly ionizing radiation can traverse human tissue, thereby enabling the use of ionizing radiation in medicine for both imaging and therapeutic procedures.

1- Directly ionizing radiation consists of charged particles, such as electrons, protons, α particles and heavy ions. It deposits energy in the medium through direct Coulomb interactions between the charged particle and orbital electrons of atoms in the absorber.

2- Indirectly ionizing radiation consists of uncharged (neutral) particles which deposit energy in the absorber through a two-step process. In the first step, the neutral particle releases or produces a charged particle in the absorber which, in the second step, deposits at least part of its kinetic energy in the absorber through Coulomb interactions with orbital electrons of the absorber in the manner discussed above for directly ionizing charged particles.

Classification of indirectly ionizing photon radiation

Indirectly ionizing photon radiation consists of three main categories:

(i) ultraviolet,

(ii) X ray,

(iii) γ ray.

Ultraviolet photons are of limited use in medicine. Radiation used in imaging and/or treatment of disease consists mostly of photons of higher energy, such as X rays and γ rays. The commonly accepted difference between the two is based on the radiation's origin. The term 'γ ray' is reserved for photon radiation that is emitted by the nucleus or from other particle decays. The term 'X ray', on the other hand, refers to radiation emitted by electrons, either orbital electrons or accelerated electrons (e.g. bremsstrahlung type radiation).

With regard to their origin, the photons of the indirectly ionizing radiation type fall into four categories: characteristic (fluorescence) X rays, bremsstrahlung X rays, photons resulting from nuclear transitions and annihilation quanta.

Classification of radiation in health aspects

1- Heavy charge particles.

2- Electromagnetic radiations.

3- Neutrons.