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Nuclear Medicine (Quickstudy: Academic)

QUICK STUDY ACADEMIC OUTLINE
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Nuclear Medicine

Essentials of Radiopharmaceuticals, Radiation Safety & Detectors, Terminology, Tools, Techniques & Equipment

OVERVIEW

Scope of Practice

- Nuclear Medicine (N.M.) involves the following aspects of skills, practice and technology:
 - patient care
 - radiopharmaceuticals
 - computer data acquisition & processing
 - radiopharmaceuticals
 - radioisotope therapy
 - radiation safety
- N.M. is a subspecialty in a multidisciplinary field, in which medicine is linked to quantitative sciences, including:
 - chemistry
 - radiation biology
 - physics
 - computer technology
- In more advanced terms, it includes:
 - molecular nuclear medicine
 - in vivo & in vitro-chemistry
 - physiology

(NOTE: See page 6 for a Glossary of Nuclear Medicine Terminology)

How N.M. Works

- Patients are administered radioactive materials, called radiopharmaceuticals, during tests for diagnosis, therapy and medical research.
- Because all diagnostic and most imaging procedures are based on the detection of radiation emitted by the radioactive materials within the body, they are classified as *in vivo* examinations.
- Most N.M. imaging procedures done for therapy are also performed within the body (i.e., in vivo), and are called *theranostics*.
- However, medical research conducted using nuclear medicine is performed outside the body (i.e., in a laboratory), and is called *in vitro*.
- Not all radiopharmaceuticals that are injected, swallowed or inhaled by the patient are radioactive. Some radiopharmaceuticals are attached to chemicals that have an affinity for particular organs, bones or other tissues of interest.
- With the radiopharmaceutical travels radioactive materials within the body. The radioactive materials then emit, or undergo, the process of **gamma ray emission**, which allows them to be **detected and imaged**.
- A **gamma**, or scintillation, camera is placed very close to capture and translate the gamma ray into photons. Until of electromagnetic radiation, which the computer then processes, into images.
- These images are then utilized to gain information regarding the organs, function and structure of the patient.
- They are then reconstructed either on film or, more commonly, stored as computer images.
- They need images to study and identify a medical problem based on the organs or tissue function (physiology).
- Different images are utilized to study different parts of the body; in other words, the radiopharmaceuticals administered depending on the molecular composition (target) for an organ/tissue of interest.
- For the human skeleton, organs, tissues, bones or other anatomical areas, they produce an image by using the total amount of radioactive material possible to complete the test.
- The purpose of the **gamma camera** is to detect and record the movement and location of radiopharmaceuticals in the body.
- With the use of other technologies, such as positron emission tomography (PET) & 2-D/3-D images, which can then reveal the structure (anatomy) and the function (metabolism, physiology, pathology) of the tissue or organ of interest.
- The images taken by the camera can be evaluated and used to detect disease, metabolic disorders, infection, bone loss, and other abnormalities.

BASIC NUCLEAR PHYSICS

Atoms

- The diagram at right demonstrates the basic composition of the atom, which includes the nucleus and the electrons.
- The electrons orbit the nucleus and the protons, while the electrons reside in the shells that orbit the nucleus.
- The electrons have discrete energy levels, depending upon which electron they reside in (i.e., shell 1, 2, 3, etc.).
- Each proton has one unit of positive charge and each electron has one unit of negative charge, the neutrons are neutral and do have no charge.
- The protons and neutrons are called nucleons.
- Each nucleon has approximately 2,000 times the mass of an electron. Thus, the mass of the nucleus is the sum of the mass of the nucleons.
- An atom chooses to be stable, yet, these differences in charge (i.e., charge not being equal) can affect the characteristics and stability of the atom.
- The proton-to-neutron ratio in the nucleus determines the stability of the atom.
- In other words, if there are more protons than neutrons—or more neutrons than protons—the atom becomes unstable.

Radioisotopes

- An unstable atom is called a **radioisotope**.
- Radioisotopes can decay by alpha, beta or gamma emissions.
- Alpha decay is a radioactive process in which an atom loses two protons and two neutrons to a more stable atom.
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- Every radioisotope has a distinct pattern for emitting gamma rays.
- Ex: "99m-Tc" emits gamma rays by emitting beta particles and gamma rays.
- Radioisotopes emit an abundance of positive energy decay by the process of positron emission or electron capture.
- Positron Decay**
- When a proton is converted into a neutron and the positive charge is ejected as a **positron**, a positive charge electron or **beta**.
- As the beta beta, a neutron is also ejected, and the energy is split between the particles.
- Now, the initial particle is neutral, has no charge and has become a neutron.
- Electron Capture**
- An electron enters in close proximity to the nucleus and is captured by a proton.
- It then combines with the proton, which yields a neutron (i.e., the -1 charge of the electron and the $+1$ charge of the proton **cancel each other out**), emitting a **neutrino**.
- Subsequent characteristics, radiations are emitted as the outer electrons move into K or L outer shells.
- Both of these decay processes—positron decay and electron capture—cause the number of protons in the nucleus by one and increase the number of neutrons by one.
- Ex: "67-Ga undergoes electron capture.
- Beta Decay**
- Conversely, radioisotopes with an abundance of neutrons undergo decay by the process of **beta emission**, which results from converting a neutron to a proton.
- beta decay process requires the nuclear particle to emit a -1 charge particle (beta), thus leaving the nuclear particle with a $+1$ charge particle (proton), which decreases the number of neutrons in the nucleus by one and increases the number of protons by one.

Alpha Decay

- Alpha decay in radioisotopes having a large and unstable mass.
- They contain a positive charge of 2 and an atomic mass of 4 .
- Gamma Emission**
- It is the decay of an excited nucleus to return to a lower energy state.
- With an excess energy and may accompany beta or alpha decay.
- Usually, to release a gamma ray, the nucleus undergoes an excess energy of an atom.

The Tech Knows

The **Tech Knows** box contains additional information on the following topics:

- How N.M. Works
- Basic Nuclear Physics
- Alpha Decay
- Beta Decay
- Gamma Emission

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Synopsis

Nuclear medicine, an exciting but complex medical field, predominates the world of healthcare technology. Let our comprehensive 3-panel (6-page) guide make it all clear! All key aspects of nuclear medicine from basic nuclear physics to diagnostic testing procedures are covered in-depth, with up-to-date information that is enhanced by useful charts and tables. Each section features "The Tech Knows" summary of critical points, set off graphically for easy reference.

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Really great study guide.

This is a nice quick reference with very general information.

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