VALUE OF GALLIUM-67 SCINTIGRAPHY IN CLINICAL SERVICE

THESIS

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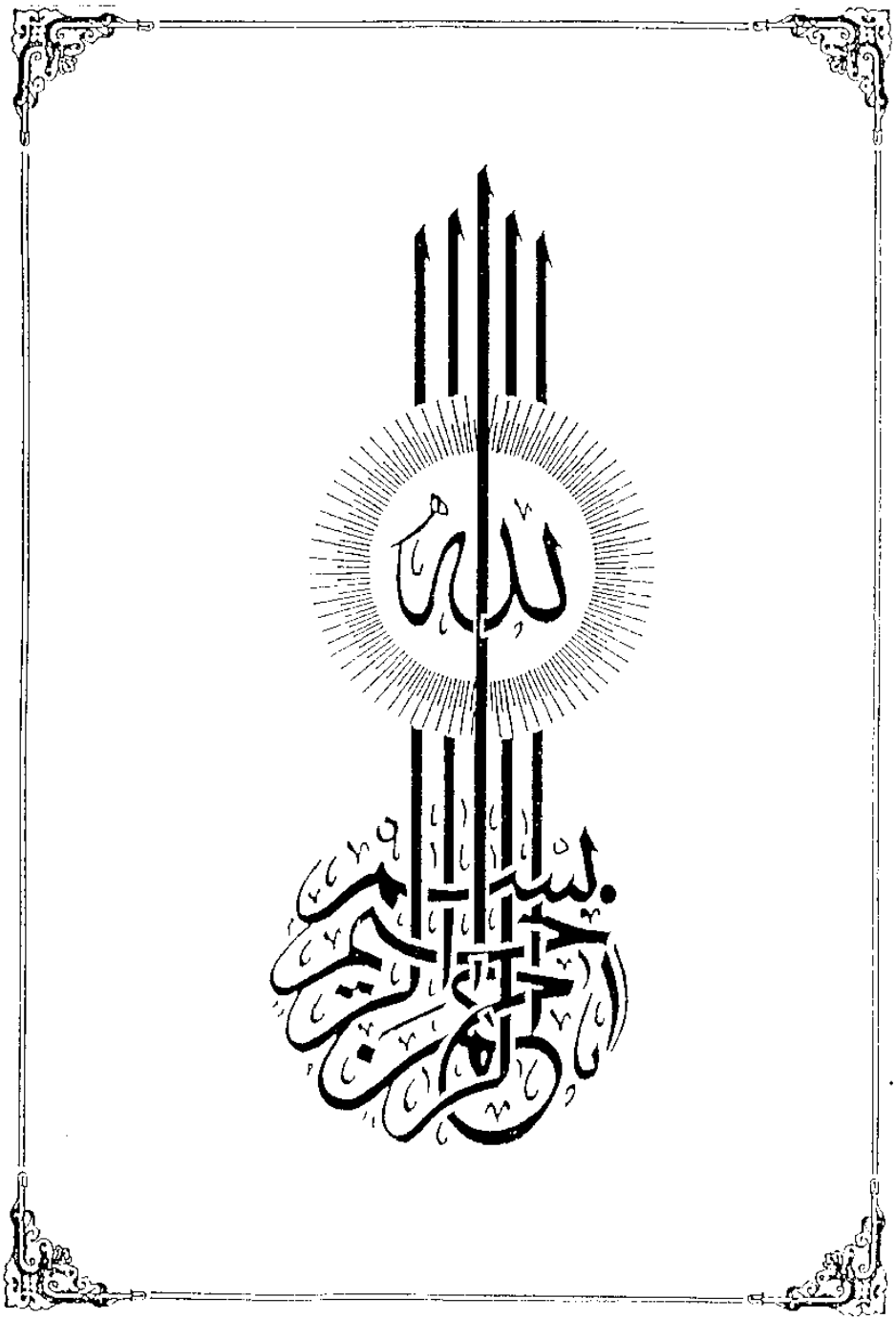

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INTRODUCTION AND AIM OF WORK

INTRODUCTION AND AIM OF WORK

Gallium-67 is one of the cyclotron products that are characterized by being expensive. However, it holds many promises for the detection, diagnosis, staging and follow up of certain neoplastic diseases. It also, plays an important role in detection of the underlying cause in cases of pyrexia of unknown etiology by revealing the source of inflammation or infection in the body.

Like all diagnostic procedures, its ultimate usefulness depends to a large extent on the awareness of the clinician to the values and limitations of gallium- 67 scanning, as well as on the experience of the nuclear medicine specialist who is reponsible for scan interpretation.

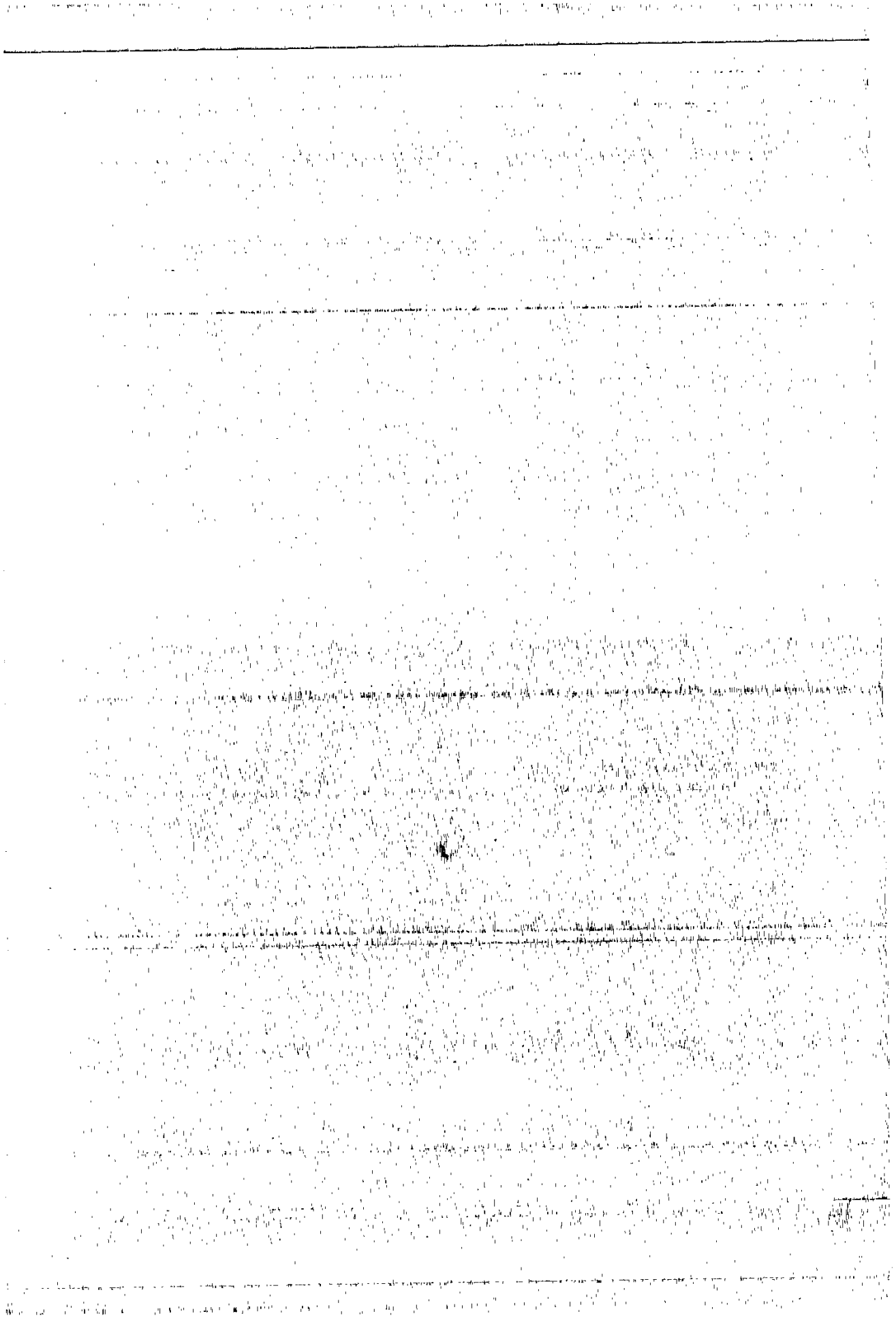
The aim of this work is to high light the clinical values and limitations of gallium- 67 scintigraphy; as well as to weigh its advantages against its relative high cost, particularly in developing countries.

CONCEPT OF GAMMA CAMERA AND SCINTIGRAPHY

CONTENTS

I- Atomic and nuclear physics considerations

II- Concepts of gamma camera and scintigraphy



GAMMA CAMERA AND SCINTIGRAPHY

I. Atomic and nuclear physics considerations:

The basic unit of mass is atomic mass unit, (amu), this equals exactly 1/12 the mass of a C12 atom.

The basic unit of energy is the electron volt (eV), this is defined as the amount of energy acquired by an electron when it is accelerated through an electrical potential of one volt.

Mass (m) and energy (E) are related to each other by Einstein's equation $E = m C^2$

Where C is the velocity of light. Accordingly, one amu is equivalent to 931.5 MeV of energy.

Electromagnetic radiations :

Electromagnetic radiations, such as X rays, and gamma rays consists of oscillating electrical and magnetic fields travelling through space with the velocity of light (3×10^8 meters/sec. in vaccum).

Electromagnetic radiations behave as discrete "packets" of energy, called photons or quanta. A photon is a packet of electro magnetic energy having no mass

or electrical charge, they travel through space at the velocity of light. The energy of radiation is proportional to the frequency of that radiation, Max Planck introduced a constant which equalizes the energy of radiation with its frequency. E = hf

Where f is the frequency; h is Planck's constant in Joules/sec. or Ergs/sec.

The X rays and gamma rays photons posses the highest energy quanta, shortest-wave length; X and gamma ray photons have energies in the KeV- MeV range.

Atoms

An atom is the smallest unit into which a chemical element can be broken down without losing its chemical identity. Protons are the nuclear particles that carry positive charges in the nucleus, their number determines the atomic number (Z) of the nucleus, which is specific of the chemical element to which the atom belongs. The total number of nucleons (protons and neutrons) is the mass number of the nucleus (A). The difference, A-Z, is the neutron number (N). The notation used to summarize atomic and nuclear

constitution is $^{A}_{Z}X$ where X represents the chemical element to which the atom belongs. A shortened but complete notation is ^{A}X. For example ^{67}Ga or alternatively it can be written as Ga-67.

Radionuclide:

A nuclide is a nuclear constitution characterized by an exact nuclear composition, same mass number A, same atomic number Z, and the same configuration of nucleons within the nucleus. Nuclides that have the same atomic number Z and different mass number A are called isotopes of the same element. Nuclides with the same mass number A and different atomic number Z are called isobars. The most stable arrangement of nucleons is called the ground state. Excited states are arrangements that are so unstable and therefore have only a transient existence before transforming into some other state. The unstable or excited nuclide is called radioactive nuclide or radionuclide.

One of the forms of energy release during radioactive transformation of radionuclide from an unstable state to a more stable state is the emission of gamma rays among other types of emissions, namely alpha particles and beta particles.

The gamma rays are considered as electromagnetic radiations having the same characteristics and properties of all other electromagnetic radiations.

Radioactive decay:

Radioactive decay is a process by which an unstable nucleus transforms into a nucleus of another element by releasing certain amounts of energy. This energy release takes the form of emission of particle radiation and photon energy. The original nucleus is the parent and the resulting nucleus after the transformation is the daughter nucleus. Radioactive decay is a spontaneous random process in that the exact moment at which a given nucleus will decay cannot be predicted. The source of energy released is a conversion of mass into energy.

Radio active decay is a process involving primarily the nucleus, whereas chemical reactions involve primarily the outermost orbital electrons of the atom. Thus the fact that an atom has a radicactive nucleus does not affect its chemical behaviour, and the chemical state of an atom does not affect its radioactive characteristics.

The radionuclide behaves in chemical and physiologic processes exactly the same as its stable nuclide.

Electron capture decay:

An orbital electron is "captured" by the nucleus and combines with a proton to form a neutron:

$$p^{+} + e^{-} \longrightarrow n + \text{neutrino} + \text{energy}$$

The neutrino (ν) is emitted from the nucleus and carries away some of the transition energy. Additional energy appears in the form of characteristic X rays and electrons, which are emitted by the daughter product when the resulting orbital electron vacancy is filled. Usually the electron is captured from orbits that are closest to the nucleus, i.e. the K and L orbits. This may be represented as:

$$^{A}_{Z}X \xrightarrow{EC} {}^{A}_{Z-1}Y$$

Electron capture decreases the atomic number by one. Electron capture is an isobaric decay mode leading to a transmutation of elements. Electron capture decay results frequently in a daughter nucleus that is in an excited state. Thus gamma-rays is also emitted. This is called (EC, gamma) decay.