International Journal of Scientific Research and Engineering Development-– Volume 6 Issue 1, Jan-Feb 2023

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Radioisotopes- Therapeutic and Diagnostic Efficacy

Dr. Rajeev Ramachandra Kolgi[1*]

[1]Department of Chemistry and Biochemistry, Government Science College Bengaluru-01. Karnataka, India.

Email : rajeevkolgi@gmail.com

Abstract

Artificially produced radioactive elements are called radio isotopes. The stable and non radioactive elements can be changed into radioactive elements by bombarding them with protons, neutrons and alpha particles. Elements from atomic number 1 to 82 are stable and with atomic number greater than 82 are unstable. The first discovered instinctive radioactive elements were among the heaviest elements. With the advent of nuclear reactors however it became possible for the scientists to bombard atoms with neutrons and alter their N: Z ratio, thereby producing artificial isotopes. This review explores radio isotopes that are frequently used in medicine, and studying reaction mechanisms of some important biochemical reactions.

Keywords: Radio Isotopes, Nuclear Reactors, Medicine, N: Z Ratio

Introduction

The phenomenon of natural radioactivity was accidentally discovered by the French scientist Henri Becquerel when he found that crystals of potassium uranylsulphate spontaneously emitted a radiation which could blacken a photographic plate. Eventually more natural radioactive elements thorium, radium and radon were discovered.

Since the use of radioactive isotopes in biology has become legion so much that it is difficult today to imagine experimental set up without their use. Radioactive isotopes have unstable nucleus that decays or emit excess radiation or energy until the nucleus becomes stable. Upto now, investigators have identified radioactive compounds which can earmark different diseases such as cancer associated with ovary, thyroid etc. In the thyroid cancer the cause is unknown or poorly understood but may involve the genetic and environmental factors. To treat the thyroid cancer patients must go through the medication, surgery and radiation therapy to kill the cancerous cell which left after the surgery. Radioactive substances administered in the different form such as orally [in form of pill], and interstitial [inserted into the cavity]. A radiopharmaceutical is a drug made up of radioactive substances i.e. radionuclide‘s, sometimes it bound with the mAb which attaches to the cancerous cell. Examples of radioactive substances are Cobalt-60, Iodine, Bismuth, Radium, Strontium and Yttrium . Conventional malignant tumor medication exhibits an absence of specificity, poor solubility and distribution, unfavorable pharmacology and high tissue harm or toxicity. Targeted drug delivery systems like passive and active targeting nanocarriers, with diameters ranging from 10-100 nm are developed to enhance the biodistribution, medicinal, therapeutic and toxicity properties of agents used in cancer diagnostics and therapeutics..

Utilization of radioactive isotopes in health of human being is considerably wide-spread and canvases therapeutic and diagnostic realm. The characteristic action could be accomplished by in vivo use of radiopharmaceuticals.

On the other hand, 'Radioimmunoassay' (RIA) is a versatile radio analytical technique which is used to measure minute (nanomolar) quantities of an analyte of clinical interest in biological specimens. This Noble prize winning technology, where ^{125}I is used as the radiotracer, is very conducive in diagnosing diseases related to hormones. A variety of radiometric assay kits have now become indispensable in pathology laboratories and regularly used for measuring various types of hormones, tumor-specific antigens, viral antigens and tumor markers.

Mode of administration

These isotopes either during diagnostic or therapeutic can be administered by inhalation (xenon, argon, nitrogen), oral (iodine) or intravenous (thallium, gallium).The most commonly used liquid radio nuclides are technetium-99, iodine-123, iodine-131, thallium-201, and gallium-67.The most commonly used gaseous/aerosol/radio nuclides are xenon-133, krypton-81m, Technetium- 99m and DTPA (diethylene-triamine-pentaacetate).

Applications of Radioisotopes

Positron emission tomography (PET), imaging has value in cardiovascular, neurological and oncological diagnosis. F-18 in fluorodeoxyglucose, that is a counterpart of dextrose has set off crucial role in identification of cancers and observing the progress in their ministartions,utilizing PET. The amalgamation of CT and PET scan in a single device furnishes coeval biochemical and structural information.

Therapeutic

Radioactive tracers are also used in many medical applications, including both diagnosis and treatment. The radiations given out by some radioisotopes are very effective in curing certain diseases such as radio cobalt (^{60}Co) is used in the treatment of brain tumor, radio phosphorus (^{32}P) in bone diseases and radioiodine (^{131}I) in thyroid cancer .It readily accumulates in the thyroid gland and can be used for monitoring the thyroid function. Some rocks contain the unstable potassium isotope ^{40}K this decays to the stable argon nuclide. By comparing the concentration both ^{40}K and ^{40}Ar the age of rocks can be measured.. ^{14}C has been used extensively to trace the progress of organic molecule through metabolic pathways. 32P is used to treat excess of red blood cells produced in the bone marrow.

Technetium-99m is one of the most useful radioisotopes for developing images of internal body organs, all is isotopes are radioactive even though is a transition metal. It has a half life of 6.02 hours. The patient is given a drink or injected with a solution containing Technetium-99m.The gamma rays emitted are detected by scanning the body with a scintillation counter. Images of organs such as liver, lungs and the heart can be obtained. Certain complex compounds of Tc bind to damaged heart tissues which can be used to diagnose heart attacks.

Radio sodium 24Na has been used to study cases of restricted circulation of blood A small quantity of NaCl solution which contain labeled 24Na is injected into the vein of the patient and X ray detector is then placed in contact with one of his feet. If blood circulation is normal the presence of radioactivity is soon discovered in the feet. It increases rapidly and becomes maximum within an hour. However if there is a circulatory impairment radioactivity will increase slowly showing that some difficulty in reaching the foot. By moving detectors in different parts of the body the position restriction can be located and the necessary treatment applied.

Pumping Action of Heart

Pumping action of heart has been studied by using radio sodium or radio iodine. The pumping action of the two sides of heart can be studied and deformities if any can be discovered.

By use of isotope tracers metabolic origin of complex molecules such as heme, cholesterol, purines and phospholipids can be determined. It was established that nitrogen atom of heme was derived from glycine.

Location and detection of brain tumour

Labeled iodine has been used to locate and detect the presence of tumour. To locate it small quantity of radioisotope of iodine is mixed with an organic dye is injected into the body of patient. Dye with radioisotope is strongly absorbed by the tumour and radiations are produced. Detection of these radiations gives important information regarding the location of tumour.

Use of radio isotopes as radioactive tracers

Radio isotopes have a property due to which they can be detected and estimated quantitatively, to trace the course of atomic species in a chemical or physical change, a small quantity radioactive isotope is mixed with non radioactive isotope. The presence of radioactive tracer is later detected in the products with help of sensitive instruments. Tracer technique is extremely useful in the study of reaction mechanisms, kinetics of biochemical reactions, and structure of compounds. The advantage of a radioactive tracer is that its presence, even in exceedingly small amounts can be easily detected.

Almost all radioactive isotopes used in tracer studies are beta emitters. Since the rate of emission of radiation continuously decreases as its concentration decreases, it is important to choose an isotope of suitable half life for tracer study. Radioisotope of very long or very short half lives is not suitable. The effect of the radiations on the living systems and on the observer must also be taken into consideration. It has been found that the radioisotope is effective only for a period of about 10 times its half life.

In studying reaction mechanisms

A series of experiments using tracers was carried out by Melvin Calvin at the University of California in order to discover the mechanism of photosynthesis. For this work, he was awarded the Nobel prize in chemistry in 1961.The mechanism of the process of photosynthesis taking place in plants has been studied by reacting carbon dioxide containing ^{18}O with water thus it can be confirmed, oxygen evolved in the process of photosynthesis comes from water and not from carbon dioxide.

A new field is targeted alpha therapy (TAT) or alpha radio immunotherapy, especially for the control of dispersed cancers. The short range of very energetic alpha emissions is targeted into cancer cells, with carrier such as a monoclonal antibody tagged with the alpha-emitting radionuclide. Lead-212 is being used in TAT for treating pancreatic, ovarian and melanoma cancers.

Biological effects of radiation

Radiation damages DNA molecule. Effects local blood supply, damages skin, produces exfoliation, hypo pigmentation, loss of elasticity of skin. Gastro intestinal reactions are very common during radio therapy can affect mucous membrane. Leucopenia and thrombocytopenia are two common unwanted secondary effects.

Radiation protection

Handling of radioactive materials should be done from maximum possible distance. Person should be shielded by lead. A lead apron is placed over the patient. The technician must stand few meters away behind lead lined door with lead glass window thereby reducing occupational exposure.

Conclusion

Imaging technologies have become increasingly sophisticated in recent years. Nuclear medicine and molecular imaging, which provides the only means of assessing physiologic changes that is a direct result of biochemical alterations at cellular and molecular levels, and in combination with traditional anatomic imaging such as computed tomography scan and magnetic resonance imaging (MRI) scan, provide precise localization of functional abnormalities. These imaging
techniques are based on the radiotracer method, and allow the measurement of tissue function in vivo and provide an early marker of disease through measurement of biochemical change. Many elements which found on earth exists in different atomic configurations used in medicine are referred to as radiopharmaceuticals which are useful to get diagnostic and therapeutic information about those tissues Imaging technologies have become increasingly sophisticated in recent years. Nuclear medicine and molecular imaging, which provides the only means of
assessing physiologic changes that is a direct result of biochemical alterations at cellular and molecular levels, and in combination with traditional anatomic imaging such as computed tomography scan and magnetic resonance imaging (MRI) scan, provide precise localization of functional abnormalities. These imaging techniques are based on the radiotracer method, and
allow the measurement of tissue function in vivo and provide an early marker of disease through measurement of biochemical change. Many elements which found on earth exists in different atomic configurations used in medicine are referred to as radiopharmaceuticals which are useful to get diagnostic and therapeutic information about those tissues Imaging technologies have become increasingly sophisticated in recent years. Nuclear medicine and molecular imaging which furnish only means of determining physiological variations that is candid result of biochemical variations at cellular levels and in blending with imaging techniques like MRI scan furnish accurate location of functional eccentries. The above mentioned imaging techniques centered on the radio tracer technique, empower the evaluation of tissue function in vivo and furnish an early marker of aliment by way of assessment of metabolic change. Numerous radio active compounds used in radiation therapy referred to as radiopharmaceuticals which are appropriate to get therapeutic and diagnostic importance of different types of tissues.

References

1.Krewski D, Lubin JH, Zielinski JM, Alavanja M, et al. Residential radon and risk of lung cancer: A combined analysis of 7 north American case-control studies. Epidemiology. 2005;16:137-145

2.Abdel Rahman RO. Introduction to Current Trends in Nuclear Material Research and Technology, Ch (1)

3. Spinks JWT, Woods RJ. An Introduction to Radiation Chemistry. Wiley-Interscience; 1990

4. Muckerheide J. Low-Level Radiation Health Effects: A Compilation of Data and Programs. Needham, Mass: RSH, Inc.; 2001.

5. Nagaratnam A. ICRP Recommendations: An Overview, ISRP (K)-BR-6; 1994.

6. Muckerheide J. Low-Level Radiation Health Effects: A Compilation of Data and Programs. Needham, Mass: RSH, Inc.; 2001

7. Alam, S.M., 1982. Assimilation of $^{14}CO_2$ in the rice plants with and without nitrogen application. Pak. J. Bot., 14: 99-101.

8. Alam, S.M. and A.B. Khan, 1966. Interaction of Fe^{55} and manganese on the uptake of Fe^{55} and yield of rice plants. Proceedings of the Agriculture Symposia, May 13-14, Atomic Energy Centre, Dhaka, pp: 95-99

9. Balock, J.W., A.K. Burditt Jr. and L.D. Christenson, 1963. Effects of Gamma radiation on various

stages of three fruit fly species. J. Econ. Entomol. 56: 42-46.

10. V.R. McCready. Milestones in nuclear medicine. Eur. J. Nucl. Med. Mol. Imaging 27, S49-S79 (2000).

11. P.S. Baker. Reactor-produced radionuclides. In: (G.A. Andrews, Ed.), Radioactive pharmaceuticals. U.S. A.E.C. Symposium Series, Oak-Ridge, Tennessee, U.S.A. (1965) 129-142.Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90.

2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.

Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90.

2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.

Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90.

2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.

Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90.

2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.

Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90

Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90

Hayter CJ. Radioactive Isotopes in Medicine: A
Review J. Clin. Path. 1960; 13:369-90.

2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.

Hayter CJ. Radioactive Isotopes in Medicine: A

Review J. Clin. Path. 1960; 13:369-90.
2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.
Hayter CJ. Radioactive Isotopes in Medicine: A Review J. Clin. Path. 1960; 13:369-90.
2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.
Hayter CJ. Radioactive Isotopes in Medicine: A Review J. Clin. Path. 1960; 13:369-90.
2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.
Hayter CJ. Radioactive Isotopes in Medicine: A Review J. Clin. Path. 1960; 13:369-90.
2. Lilley J.S. Nuclear Physics- Principles and Applications. John Wiley and Sons, Ltd, Singapore (2002); Ananthakrishnan M, Seminar talk on Applications of Radioisotopes and Radiation Technology.1.S. Jurisson, D. Berning, W. Jia and D. Ma. Coordination compounds in nuclear medicine. Chem. Rev. 93, 1137-1156 (1993).