RADIOPHARMACEUTICALS IN PHARMACEUTICAL SCIENCE

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ABSTRACT

Modern diagnostic and therapeutic procedures using radiopharmaceuticals' original radiotracers are made possible by the medical specialty known as radiopharmaceuticals (Nuclear Medicine) (drugs linked to a radioactive isotope). Since radiopharmaceuticals are regarded as a unique class of medications on a global scale, each member nation has created a set of laws that govern their production and usage. Mild doses of the radiopharmaceuticals used in diagnostic exams are given. Thus, they have neither the required pharmacological action nor any undesirable side effects or severe adverse responses. The main drawback of their use is that they affect biodistribution, which could lead to incorrect diagnoses. Nuclear medicine is expanding significantly, but it is also impacted by the emergence and development of novel radiopharmaceuticals in both the diagnostic and therapeutic domains, as well as by the use of new multimodal imaging techniques (SPECT-CT, PET-CT, PET-MRI, etc.). It is essential to understand the restrictions placed on such approaches, the distribution and potential physiological changes caused by radiopharmaceuticals, the contraindications and unfavourable effects of radiological contrasts, and the potential for both of these factors to interfere.

Keywords- Radiopharmaceuticals, imaging, disease, diagnostic, therapeutics, techniques.

I.INTRODUCTION

A group of pharmaceutical drugs that contain radioactive isotopes is known as radiopharmaceuticals, sometimes known as beneficial radio compounds. Isotopes are radioactive atoms that are employed as therapeutic and diagnostic tools (radionuclides). Radiopharmaceuticals, which contain radioisotopes used in many therapeutic settings for diagnosis and treatment, produce radiation itself. The area of pharmaceutical medicine that specialises in these agents is called radiopharmacology.

International, national, and regional authorities must grant licences for the establishments and practises involved in the manufacturing, use, and storage of radiopharmaceuticals. There are numerous different methods they'll rush to the sufferer.

Even while not all medical isotopes are radioactive, radiopharmaceuticals are the oldest and still most frequently used class of medications. They are the radiotracers used to diagnose pathology in bodily tissues [1].

II.CHARACTRISTICS OF RADIOPHARMACEUTICALS

A class of medicines known as radiopharmaceuticals includes various beneficial forms. These organisations use radioactive isotopes, sometimes known as radioisotopes, for therapeutic interventions as well as clinical diagnosis. Radiopharmaceuticals are frequently used in clinical diagnostics to examine the function of the liver, lungs, and kidneys, blood flow to the brain, bone growth, the anticipated effects of surgery, and changes since treatment. Radiopharmaceuticals are frequently used in the treatment of inflammatory diseases, cancer and neoplasms, thyroid disorders, and bone metastases as palliative care. Radiopharmaceuticals actively release radiation.

Depending on the type of radiation the substance emits, it may be used for medical diagnosis or treatment. In contrast to a substance that emits alpha particles, which is typically utilised for therapeutic interventions, a

substance that emits beta or gamma radiation particles is used for diagnosis. Some properties of radiopharmaceuticals include beta and alpha particles. The following are some of the most desirable qualities of medicinal substances.

A. Half-Life Time

Depending on how the property is being used, the optimal pharmaceutical should have a short or lengthy physical half-life. The half-life time is the amount of time required for radioactive nuclei to decay to half their original radioactive lifespan. To effectively control radiation doses and to degrade quickly during diagnostic imaging, radiopharmaceuticals used for diagnostic purposes should have a short physical half-life. Radiopharmaceuticals used for therapeutic purposes should have a long physical half-life since a short decay period would reduce the compound's therapeutic characteristics and make it less effective over time. The effective half-life period should even be sufficient to the examination quantity in diagnostic imaging. The amount of time it takes for radiation from specific radioactive chemicals spread throughout the body to decay to half is known as the effective half-life. By doing this, radiation overexposure to the form outside of the examination amount is eliminated.

B. Gamma Radiation Emission

Radiopharmaceuticals' diagnostic capabilities depend on gamma or beta particle emission. Lightweights called gamma rays travel at wavelengths very distinct from those of actinic radiation. By observing the gamma radiation emissions, SPECT scans—single proton computed axial tomography scans—and PET scans—positron emission tomography scans—are frequently utilised in diagnostic procedures. Gamma cameras used in SPECT scans will monitor the radiolabelled chemicals injected into the patient's body's gamma emissions. Description scans use gamma radiation emission to diagnose and monitor the development of heart conditions, bone ailments, movement disorders, dementia, and Parkinson's disease. Gamma rays are not measured by PET scans. Positrons, which are minuscule particles, are produced as the radio-labelled chemical decays during a PET scan. The body's electrons and protons combine to create photons, which can be detected and used to make images of interior organs.

C. Auger Electrons or Alpha Particles

For molecular nuclear therapies, Auger electrons or alpha particles are released for therapeutic purposes. With this method, they are directed toward a specific area, such as a tumour. These electrons attach to an organic molecule and are then domestically released over a specific period of time to the damaging tissue. The radioactive emissions only treat or eliminate the harmful bulk in the local tissue, leaving healthy tissues and organs unharmed.

D. Specific Activity

The number of radiations per unit mass of the component or compound is referred to as the specific activity. Radiopharmaceuticals must typically have high specific activity to localise to the receptor location.

E. Localize Largely and Quickly

Radiopharmaceutical substances should promptly and primarily localise to the receptor location. Since radiation can be harmful to the body's healthy tissues, radiopharmaceuticals are often utilised in confined therapeutic zones. This will keep healthy tissue and organs safe from hazardous radiation while also concentrating treatment to the precise area needed. Quickly localising to the treatment area enables the treatment to take place more quickly, which is frequently necessary in nosology or life-saving procedures like tumour removal.

F. Stability

Particularly in diagnostic imaging, radiopharmaceutical stability is crucial. It is possible for light, temperature, and hydrogen ion concentration balances to have an impact on radioisotope stability. Metabolically-decomposed radiopharmaceuticals used in diagnostic imaging may result in undesired radiation distribution and reduced image quality if these effects are not taken into account during the production and storage of compounds, making diagnosis challenging.

G. Cost, Handiness, And Care

Pharmaceutical substances must have certain design properties. The convenience, portability, and cost of production are crucial considerations, even if the planning of a compound heavily rely on the qualities previously mentioned. Making useful radiopharmaceuticals depends largely on availability and production costs, much like any clinical test or treatment. Pharmaceutical manufacturing companies should consider the cost of production as well as the accessibility of parts, such as the appropriate nuclide needed for therapy or diagnosis, on a large scale. Correct storage accessibility still needs to be taken into account. In order to reduce potential exposure to the lowest and safest levels, radiopharmaceuticals must be prepared to be stored in a certain environment, such as a sealed instrument.

H. Safety

Like many pharmaceutical production rules and procedures that are in place to handle the development of substances, radiopharmaceuticals are a risky business. To safely handle any pharmaceutical chemicals, good manufacturing practises should be followed, such as adequate sanitization and accurate labelling on supplies. The ALARA principle, which stands for As Low As Responsibly Achievable, should be applied explicitly to radiopharmaceuticals. The most appropriate shielding from the radiation source must be provided, the personnel must be kept as far away from the radiation source as possible, and exposure to radiation must be reduced as much as is humanly possible.

In the pharmaceutical industry, radiopharmaceuticals are used for a variety of purposes, including the diagnosis of cardiopathy and thyroid disease as well as the treatment of malignant tumours and cardiovascular diseases. For radiopharmaceuticals to successfully diagnose and treat medical issues, certain qualities must be present in their composition and production. Half-life, electromagnetic radiation, alpha particles, particular activity, localisation, stability, preparation style and care, and all of these factors play crucial roles in the development and composition of medicinal compounds [2].

III. DRUG NOMENCLATURE FOR RADIOPHARMACEUTICALS

Radiopharmaceuticals' drug nomenclature is standardised, much as other pharmaceutical medications, however alternative standards coexist. The radioisotope is listed in parenthesis with no superscript after the basic medication name in the International Non-proprietary Name (INN), which also includes the ligand (if any). Due to the use of square brackets and superscript in chemical nomenclature (such as IUPAC nomenclature), it is usual to see them superimposed on the INN name. The base medicine name is provided in the United States Pharmacopeia (USP) name, which is followed by the radioisotope (represented by an element symbol, space, and mass number) without parentheses, hyphens, or superscripts, and then the matter (if any). Despite their being represented together and as the same in certain publications, the USP style and the INN style are not the same (e.g., AMA, whose style for radiopharmaceuticals matches the USP style). The USAN Council may have the United States Pharmacopeial Convention as a sponsor, and the USAN name for a particular medicine is typically equivalent to the USP name [3-6].

IV. ROLE OF RADIOPHARMACEUTICALS

To target particular organs, tissues, or cells within the organic structure, radiopharmaceuticals are radioisotopes that are absolutely bound to biological molecules. This radioactive drug is used to diagnose illnesses and, eventually, treat them medically.

The number of radiopharmaceuticals being used in clinical settings is quickly increasing, giving the medical community greater access to detailed information on the traits of the many tumour forms.

A pharmaceutical is defined as a substance made of a radionuclide and a carrier molecule that has a high affinity, or binding power, for a tissue or a specific function of an individual's organ. If an isotope exhibits the necessary biological qualities, it should also be the only component.

Scintigraphy, a technique that uses radiopharmaceuticals to create images of organs or tissues of interest. The gamma rays released by the isotope can be found using a type of medical gadget called a gamma camera. It creates images that replicate the function of the organ or tissue being studied in an incredibly non-invasive way.

Technetium-99m is the radioisotope that is most frequently utilised in diagnostic medicine. Too many specific molecules are connected, allowing for the diagnosis of a wide range of disorders, including some types of cancer. For instance, technetium-99m-MDP (methylene diphosphonate) is frequently used to identify cancer-related bone metastases.

A. Diagnosis in Cancer

Imaging tests are frequently required for the detection of cancer, and they frequently involve very little radiation. Clinical decision-making, along with medical care and follow-up, requires procedures including X-rays, computerised tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and single-photon emission CT (SPECT).

❖ Imaging Tests

The identification and treatment of cancer patients depend heavily on the taking of inside body pictures. One of the fundamental steps in the clinical therapy of cancer is the use of diagnostic imaging. Diagnostic imaging and medical tests are crucial to screening, staging (determining the extent of the disease, such as how large the tumour is and if it has spread beyond the initial site), follow-up, medical treatment planning, evaluation of medical care response, and long-term patient care.

The location of the initial tumour and its size and extent of spread to surrounding tissues, as well as to various organs and body structures, must be accurately identified. Determine the therapeutic technique that will be needed and the prognosis are of the utmost importance, according to the associate degree applicable identification.

❖ Early identification

The stage of the disease at the time of detection has a significant impact on a cancer patient's chance of recovery. When a tumour is found in its early stages, before it has grown or spread, it has a better chance of being effectively treated. The early detection of cancer depends on many important factors, including the ability of patients and medical professionals to recognise warning signs, screening of populations at risk, the use of diagnostic tools to differentiate between cancer and other processes, and precisely confirming the location and extent of the tumour. While the range of positron emission tomography (PET) and single photon emission tomography (SPECT) is only a few millimetres, contemporary diagnostic imaging techniques like magnetic resonance imaging (MRI) and X-ray computed tomography (CT) allow for the differentiation of tissues down to a millimetre.

❖ Anatomy Versus Function

Diagnostic imaging can be broken down into two main categories: those that produce images that are helpful or informative and those that delineate anatomical details with extreme precision.

The first method (using CT and MRI) will provide excellent details on lesion location, size, shape, and structural alterations to surrounding tissues, but only provides a limited amount of information about the tumour’s operation.

However, it cannot provide anatomical information. The second method (using PET and SPEC) will shed light on the tumour physiology down to the molecular level.

By combining these two approaches, it is possible to combine anatomy and performance in a single strategy. The development of such "hybrid" imaging has made it possible to characterise tumours at every stage.

❖ Role of Nuclear Techniques

Multiple diagnostic imaging procedures that use various types of radiation, such as X-rays (CT and radiography) and gamma rays, have totally changed how cancer patients are managed (PET and SPECT). Technologies like positron emission tomography (PET), which rely on the use of radiopharmaceuticals, represent a turning point in the field since they allow researchers to grasp what is happening at the molecular level in a particular cell or tissue without having to open the human body. The data from these techniques have allowed for significant advancements in patient management and, as a result, the effective distribution of care resources.

B. Diagnosing of Cardiovascular Diseases

Cardiovascular disorders are the leading cause of death worldwide, according to the UN organisation. Radiation-based diagnostic methods are crucial to the management of these disorders and have significantly lowered their associated morbidity and death over the past 20 years.

Radiation is required in almost all cardiovascular disease diagnostic imaging techniques. Invasive and non-invasive techniques will be separated out.

Through the use of invasive procedures, a tube—an extended, thin, adaptable tube—is put into a rib to the centre. A different substance is put into the bloodstream through this catheter, and then X-rays are used to take

images of the heart's architecture and the arteries that provide blood to the heart muscle to determine how open or "patent" they are. The "gold standard" for assessing the viscus anatomy and, consequently, the severity of a physiological pathology is this method, known as viscus catheterization. It is advised for a variety of purposes, the most prevalent of which is to assess pain. However, because it is intrusive, its widespread use is prohibited.

Instead, non-invasive viscus imaging methods are becoming more popular. These techniques will outline the architecture of the vasculature, evaluate the patency of the coronary arteries, the insertion of the heart muscle, and the function and metabolism of the heart muscle. Some of them make use of radiation and coronary CAT roentgenography, a cardiac imaging examination that can be used to determine whether plaque build-up has caused the patient's coronary arteries to become narrowed. Others use non-nuclear methods include diagnostic techniques, ultrasound images of the heart, or vascular resonance imaging, a technique that uses radio frequency energy pulses.

❖ **Key Methods of Nuclear Medicine**

Studies in the field of nuclear medicine evaluate the flow of blood through the heart's centre muscle's blood arteries, also known as heart muscle blood flow. Heart muscle insertion imaging is the method of nuclear medicine that is most frequently employed. The images captured using this approach are frequently used to evaluate the blood flow to the central muscle in conjunction with treadmill or stationary bike exercise.

A small amount of a drug is injected into the bloodstream to create these images. The canter’s uptake of the imaging material is then observed using a scanning equipment (such as a gamma camera). The centre muscle may not get enough blood supply if an arterial blood artery is critically blocked. This decrease in blood flow is often detected on the photographs.

Studies using myocardial insertions will identify portions of the heart muscle that don't receive enough blood supply and people areas that might be scarred from a heart failure. This gives the necessary information to help decide whether individuals have an increased risk of developing heart failure and will be candidates for invasive procedures like coronary roentgenography, surgical operation, or surgery (a procedure to open up blocked or restricted arteries).

C. Diagnosing of Degenerative Diseases

Imaging techniques are essential for diagnosing and treating chronic conditions that affect the musculoskeletal system and brain, such as Parkinson's disease and Alzheimer's disease (osteoporosis and arthritis).

❖ **Nuclear Medicine and Brain Disorders**

Neurodegenerative brain illnesses, which primarily affect the elderly, have become increasingly costly for society during the past thirty to forty years, coinciding with the global expansion in lifespan. The most prevalent and well-known of these conditions, Alzheimer's disease targets both the mental and emotional health of its sufferers, likely wreaking havoc on both their personal and family lives.

The diagnosis of neurodegenerative illnesses is extremely challenging. Patients often only exhibit mild and ambiguous signs and symptoms, and even the results of diagnostic imaging don't always seem to be conclusive. Patients often have adequate symptoms by the time the condition is clearly visible in pictures, allowing for an accurate diagnosis.

Over the past forty years, diagnostic imaging has played a variety of roles in the study of Alzheimer's disease. Initially, CAT scans and then magnetic resonance imaging (MRI) were used to rule out various dementedness reasons. More recently, a variety of imaging techniques, including structural and functional imaging, antilepton emission pictorial representation studies, and others, have revealed distinctive abnormalities within the brains of Alzheimer's patients. However, because each imaging approach has unique strengths and shortcomings, none will be able to perform all tasks.

Additionally, imaging is essential to analysis since it helps answer many scientific questions and sheds light on the effects of Alzheimer's disease and its origin. it has long been a tool for drug research, and clinical trials increasingly depend on it to make sure for medicine.

D. Nuclear Medicine and Disorders of the musculoskeletal System

Nuclear diagnostic methods are also pertinent for illnesses that affect the system. The most prevalent of these is pathology, which is more likely in girls who are of reproductive age. This disease is characterised by insufficient bone growth, excessive bone loss, or a combination of both, leading to increased risk of hip, spine, and carpal bone fractures. X-ray techniques frequently measure bone density. The best method is dual-energy x-ray

absorptiometry scanning, which compares the patient's bone density to that of healthy individuals and people of a comparable age to detect minute changes in the patient's bone mass.

E. Diagnosis of Infectious Diseases

Radiation-based in-vivo and in-vitro diagnostic techniques are used to identify infectious illnesses. In-vivo techniques produce images of living things and are frequently used to identify disorders like infectious disease or osteitis. Utilizing test tubes or culture dishes, in-vitro procedures are utilised to diagnose conditions like HIV, viral haemorrhagic fever, and protozoal infections.

Worldwide, infectious diseases claim the lives of thirteen million people annually, the majority of them in developing nations. The most prevalent and serious of those illnesses include infectious disease, protozoal infection, and the human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS). A total of 36 million people worldwide with HIV, with 2 million newly infected in 2014.

With 11% of all fatalities, tuberculosis is the second most lethal infectious disease. In contrast to the next illness on the list, protozoal infection, which infected 198 million people in 2013 and claimed 584,000 deaths, this illness claimed about 1.5 million lives. The problem is made worse by immigration from low-income to high-income nations, the possibility of HIV/AIDS co-infection, and the emergence of drug-resistant infectious disease strains.

Only lower metabolic process infections (including pneumonia), HIV/AIDS, and protozoal infections account for the majority of global health care costs, totalling over US$34 billion, placing them third after cancer and cardiopathy.

❖ How Nuclear Medicine Helps Diagnose Infectious Diseases

The medical toolbox includes both in-vivo imaging and in-vitro methods for diagnosing infectious disorders. Imaging and molecular laboratory tests used in in-vitro methods make it easier to detect infections and control drug resistance.

However, the gold standard method for detecting infections is still in vivo methods like radiolabeling white blood cells. This approach depends on leukocytes' (white blood cells') capacity to travel into contaminated areas and eradicate microorganisms. Using this method, the patient receives a second injection of white blood cells that have been labelled with the medicinal isotope Technetium-99m. The identification of the infected sites is subsequently made possible by imaging the places where the cells unfold within the body, a process known as focused uptake.

In order to diagnose and monitor a variety of illnesses, such as osteitis (infections of the bone that can affect the entire structure, down to the bone marrow), fevers of unknown origin, and contaminated tube prosthetic devices, nuclear medicine investigations and resonance imaging are used. The latter are bacterial infections that may develop after procedures to replace or bypass blood arteries that have been damaged or diseased by a graft.

One of these infections, which are thought to be extremely challenging medical problems, is brought on by a microbe that is transported through the bloodstream from a distant location, by vaccination from direct trauma, a contiguous focus of infection, or infection after surgery. Osteitis is not often easy to diagnose, hence radiological techniques are sometimes carried out as part of the identification.

Particle emission A spread of infections, such as large-vessel vasculitis, stomach infections, such as inflammatory gut illness, and pectoral and soft-tissue infections, can be accurately diagnosed by visual depiction. It is also beneficial for malignant neoplastic illness, aggressive non-lymphoma, Hodgkin's tumor-induced fever brought on by Hodgkin's disease, and body part cancer. Due to the relatively low prevalence of white blood cell processes in an extremely clinical situation, in-vitro or in-vivo tagged white blood cell methods are of limited cost in patients with fever of unknown aetiology.

F. Diagnosing and Treating Disease in Children (Paediatric Illnesses)

Diagnostic imaging for spotting illness in children requires additional safety precautions and care. Radiation doses should be kept as low as possible and exams should be conducted without deviation so that the benefits outweigh the risks by a wide margin.

A sick child should not be treated the same way as a sick adult. A child cannot just imagine a tiny adult. A customised approach is required when using nuclear medicine procedures to treat children. When using radionuclides for identification and medical care, doctors and technicians must possess a wide variety of skills and competencies in order to appropriately manage ill children. The dangerous nature of radionuclide use necessitates knowledge of radiation safety issues as well as technical expertise to ensure quality control.

Exams of new-borns, toddlers, and teenagers are referred to as "paediatric medical speciality" exams (up to the age of 18). When doing routine diagnostic imaging tests designed for adults, diseases affecting children may

show problems and anomalies that are not obvious or may go undetected. On average, children are shown to have more inborn anomalies and biological process malformations than adults.

For example, cancer, which can be contagious, non-contagious, inherited, or occur during children, is one of the risky disorders that paediatric nuclear medicine specialised imaging is used to assist diagnose. Nuclear medical expert imaging techniques can be used to evaluate children with cancer and other disorders that affect organ systems such the kidney, urinary bladder, bones, liver, gallbladder, duct tract, heart, lungs, and thyroid. The high volume of these cases has often resulted in doctors and technologists caring for ailing children having a strong experience base and skill set.

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Some of the medical specialties used to diagnose and treat inborn and acquired system diseases as well as childhood cancers include planar nuclear medical specialty imaging techniques, SPECT and SPECT/CT (computed tomography), positron emission tomography (PET)/CT, and nuclear medicine therapy technology.

Nuclear medicine scans are frequently employed to detect diseases like urinary blockage within the urinary organ, the flow of urine from the bladder into the urinary organ, bone cancer, infections and trauma, duct haemorrhage, jaundice in new-borns and older children, inborn adenosis, and most importantly cancer and its metastasis within the body [10–15].

V. THERAPEUTIC APPLICATIONS OF RADIOPHARMACEUTICALS

A. Treatment of Hyperthyroidism

It is frequently used to treat hyperthyroidism with 131-iodine. Upon oral administration of the radionuclide, the hyperactive gland absorbs about 60% of the radiation. The main drawback of radioiodine medical treatment is the high prevalence of early and late adenosis, necessitating careful patient monitoring following treatment. As a result, radioiodine treatment is now not just for elderly people; it is also being used to treat adolescents and even young children.

B. Treatment of Thyroid Carcinoma

For many years, radioiodine has been used to treat differentiated thyroid malignant neoplastic illness, a tumour that can spread to the bones, lungs, and various soft tissues. However, it's slow-growing and the prognosis is reasonable, allowing for long-term follow-up with treated individuals. Repeated radionuclide imaging with radioiodine will evaluate how well treatment is working. If necessary, advanced or resistant instances may also require therapeutic doses of 131I.

C. Treatment of Neuroendocrine

Tumours The neurochemical nor-adrenaline and the adrenergic somatic cell blocker Metaiodobenzyleguanidine share structural similarities. The endocrine system and other tissues with strong sympathetic innervations absorb it because of its structural similarity, but unlike nor-adrenaline, it is not metabolised and is essentially expelled unchanged in the excreta. System tumours include metastatic tumours, tumour tumours, and medullary malignant neoplastic disease of the thyroid have all been successfully treated with 131I-metaiodobenzyleguanidine (131I-MIBG). Numerous substances, including 161-Terbium-diethylenetriaminepentaacetic acid-octreotide and 111-Indium-diehylnetriaminepentaacetic acid (111In-DTPA) for tumours containing somatostatin receptors, are being studied as possible substitutes for 131I-MIBG.

D. Treatment of Bone Tumours

Patients with prostate, breast, and lung cancer frequently develop bone metastases, and managing bone pain in these patients may be a significant therapeutic challenge. The basis of treatment continues to be analgesic medication and external beam actinotherapy, however the percentage of the body that can be treated is constrained. Bone metastases can be treated with a variety of beta emitting radionuclides in a wide range of chemical formulations. We distribute 32P, 89Sr, 186-Rhenium, and 153-Samaraum.

E. Treatment of Myeloproliferative

Diseases For more than 50 years, 32P has been used to treat a variety of specialised medical conditions. Following that, bone absorption and selection by rapidly growing tissue are both targets for 32P, an inorganic phosphate. This procedure delivers a significant radiation dosage to the bone marrow, which slows the proliferation of the haemopoietic cell lines. The first use of 32P was for the management of polycythaemia vera. The quantity of red cells in the circulation has an abnormally high increase under these circumstances. However, therapy, radioactive phosphorus treatment, and bloodletting all result in a significant lengthening of life [7-9].

- **SOME SPECIFIC RADIOPHARMACEUTICALS**

Name of radio isotope	**Investigation**	**Route/mode of administration**	**In vitro model / in-vivo model**	**Imaging (Yes)/ non-imaging (No)**
Ca-47-Ca^{2+}	Osteo Metabolism	Intravenous	Invitro model	No
C11-L-methyl-methionine	Brain Imaging of Tumours, Parathyroid Imaging	Intravenous	In vivo model	Yes
C14-Glycocholic acid	Small Intestine Bacterial Overgrowth Breathing Test	Oral	Invitro model	No
C14-PABA (para-amino benzoic acid)	Pancreatic Research	Oral	Invitro model	No
C14-Urea	Testing Your Breath for Helicobacter Pylori	Oral	Invitro model	No
C14-d-xylose	Small Intestine Bacterial Overgrowth Breathing Test	Oral	Invitro model	No
Cr51-heart scan/blood volume scan	Heart Scan, Locations of Sequestration, And Gastrointestinal Blood Loss. RBC Volume	Intravenous	Invitro model	No
Cr51-Cr^{3+}	Lack Of Intestinal Protein	Intravenous	Invitro model	No
Cr51-EDTA (Ethylenediaminetetraacetic acid)	Measurement Of the Glomerular Filtration Rate.	Intravenous	Invitro model	No
Co57-Cyanocobalamin (Vitamin B_{12})	To Facilitate Gastrointestinal Absorption	Oral	Invitro model	No
Co58 Cyanocobalamin (Vitamin B_{12})	To Facilitate Gastrointestinal Absorption	Oral	Invitro model	No
F18-FDG (Fluorodeoxyglucose)	Cancer Imaging	Intravenous	In vivo model	Yes
F18-Sodium Fluoride	Bone Scan	Intravenous	In vivo model	Yes
F18-Fluorocholine	Imaging Of Prostate Tumours	Intravenous	In vivo model	Yes
F18-Desmethoxyfallypride	Imaging Of Dopamine Receptors	Intravenous	In vivo model	Yes
Ga67-Ga^{3+}	Cancer Imaging	Intravenous	In vivo model	Yes
Ga67-Ga^{3+}	Imaging Of Infection and Inflammation	Intravenous	In vivo model	Yes

Ga68-Dotatoc or Dotatate	Imaging Of Neuroendocrine Tumours	Intravenous	In vivo model	Yes
Ga68-PSMA	Imaging For Prostate Cancer	Intravenous	In vivo model	Yes
H3-water	Sum Of Bodily Water	Oral or Intravenous	Invitro model	No
In111-DTPA (diethylenetriaminepenta-acetic acid)	The Ventricular-Peritoneal Shunt (Laveen Shunt)	intraperitoneal injection	In vivo model	Yes
In111-DTPA (diethylenetriaminepenta-acetic acid)	Cisternography	Intra-cisternal	In vivo model	Yes
In111-Leukocytes	Imaging Of Infection And Inflammation	Intravenous	In vivo model	Yes
In111-Platelets	Imaging Thrombus	Intravenous	In vivo model	Yes
In111-Pentetreotide	Imaging Of the Somatostatin Receptor	Intravenous	In vivo model	Yes
In111-Octreotide	Imaging Of the Somatostatin Receptor (Octreoscan)	Intravenous	In vivo model	Yes
I123-Iodide	Thyroid Absorption	Oral or Intravenous	In vivo model	No
I123-Iodide	A Thyroid Scan, Imaging of Thyroid Metastases	Oral or Intravenous	In vivo model	Yes
I123-o-Iodohippurate	Kidney Imaging	Intravenous	In vivo model	Yes
I123-MIBG (m-iodobenzylguanidine)	Imaging Of Neuroectodermal Tumours	Intravenous	In vivo model	Yes
I123-FP-CIT	Imaging Of Parkinson's Disease Using SPECT	Intravenous	In vivo model	Yes
I125-fibrinogen	Clot Imaging	Intravenous	In vivo model	Yes
Fe59-Fe^{2+} or Fe^{3+}	Metabolism Of Iron	Intravenous	In-vitro	No
Kr81m-Gas	Imaging Of Lung Ventilation	Inhalation	In vivo model	Yes
Kr-81m-Aqueous solution	Imaging Of the Lung Perfusion	Intravenous	In vivo model	Yes
^{177}Lu-DOTA-TATE	Tumours Of the Pancreatic and Digestive Systems (GEP-Nets)	Intravenous	In vivo model	Yes
N13-Ammonia	Imaging Of Myocardial Blood Flow	Intravenous	In vivo model	Yes
O15-Water	Imaging Of Cerebral Blood Flow, As Imaging of Myocardial Blood Flow	Intravenous	In vivo model	Yes
P32-Phosphate	Polycythaemia And Associated Conditions	Intravenous or Oral		
Ra223 cation ($^{223}RaCl_2$)	Metastatic Bone Cancer	Intravenous		
Rb-82 chloride	Cardiovascular Imaging	Intravenous		
Se75-Selenorcholesterol	Imaging Of the Adrenal Gland	Intravenous	In vivo model	Yes
Se75-SeHCAT (23-Seleno-25-homo-tauro-cholate)	Absorption Of Bile Salts	Oral	In vivo model	Yes

$Na22\text{-}Na^{+}$	Study On Electrolytes	Oral or Intravenous	In vivo model	No
$Na24\text{-}Na^{+}$	Study On Electrolytes	Oral or Intravenous	In vivo model	No
Tc99m-pertechnetate	Imaging Of the Thyroid and Thyroid Uptake Imaging of The Stomach and Salivary Glands Imaging Of The Meckel's Diverticulum Brain X-Rays Cystogram With Micturition Imaging Of Blood Flow On The First Pass Peripheral Vascular Imaging On The First Pass	Intravenous	In vivo model	Yes
Tc99m-pertechnetate	Lacrimal Photography	Eye drops	In vivo model	Yes
Tc99m-Human albumin	Cardiovascular Imaging	Intravenous	In vivo model	Yes
Tc99m-Human albumin	Vascular Imaging of The Periphery	Intravenous	In vivo model	Yes
Tc99m-Human albumin macroaggregates or microspheres	Perfusion Imaging of The Lung	Intravenous	In vivo model	Yes
Tc99m-Human albumin macroaggregates or microspheres	Imaging The Perfusion of The Lungs with Venography	Intravenous	In vivo model	Yes
Tc99m-Phosphonates and phosphates (MDP/HDP)	Bone Scans	Intravenous	In vivo model	Yes
Tc99m-Phosphonates and phosphates	Cardiovascular Imaging	Intravenous	In vivo model	Yes
Tc99m-DTPA (Diethylenetriaminepenta-acetic acid)	Kidney Imaging Studies Of First-Pass Blood Flow Brain X-Rays	Intravenous	In vivo model	Yes
Tc99m-DTPA (Diethylenetriaminepenta-acetic acid)	Imaging Of Lung Ventilation	Aerosol inhalation	In vivo model	Yes
Tc99m-DMSA(V) (dimercaptosuccinic acid)	Cancer Imaging	Intravenous	In vivo model	Yes
Tc99m-DMSA(III) (dimercaptosuccinic acid)	Kidney Imaging	Intravenous	In vivo model	Yes
Tc99m-Colloid	A Bone Marrow Scan	Intravenous	In vivo model	Yes
Tc99m-Colloid	Gi Bleeding	Interstitial	In vivo model	Yes
Tc99m-Colloid	A Lymph Node Scan	Oral	In vivo model	Yes
Tc99m-Colloid	Imaging Of Oesophageal Transit and Reflux Imaging of Gastric Emptying	Eye drops	In vivo model	Yes
Tc99m-HIDA (Hepatic Iminodiacetic acid)	Lacrimal Photography	Intravenous	In vivo model	Yes
Tc99m-Denatured (heat damaged) red blood cells	Imaging Of the Functional Biliary System	Intravenous	In vivo model	No

Tc99m-Whole red blood cells	Gut Bleeding Cardiovascular Imaging Vascular Imaging of The Periphery	Intravenous	In vivo model	Yes
Tc99m-MAG3 (mercaptoacetyltriglycine)	Kidney Imaging Imaging of Blood Flow's Initial Pass	Intravenous	In vivo model	Yes
Tc99m-Exametazime (HMPAO)	Imaging Of Cerebral Blood Flow	Intravenous	In vivo model	Yes
Tc99m-Exametazime labelled leucocytes	Imaging Of Infection and Inflammation	Intravenous	In vivo model	Yes
Tc99m-Sestamibi (MIBI - methoxy isobutyl isonitrile)	Thyroid Imaging Unfocused Tumour Imaging Thyroid Tumour Imaging Viewing Breasts Cardiovascular Imaging	Intravenous	In vivo model	Yes
Tc99m-Sulesomab (IMMU-MN3 murine Fab'-SH anti-granulocyte monoclonal antibody fragments)	Imaging Of Infection and Inflammation	Intravenous	In vivo model	Yes
Tc99m-Technegas	Imaging Of Lung Ventilation	Inhalation	In vivo model	Yes
Tc99m-Human immunoglobulin	Imaging Of Infection and Inflammation	Intravenous	In vivo model	Yes
Tc99m-Tetrofosmin	Thyroid Imaging Cardiovascular Imaging	Intravenous	In vivo model	Yes
Tc99m-ECD (Ethyl Cysteinate Dimer)	During Brain Imaging	Intravenous	In vivo model	Yes
Tl201-Tl^{+}	Unfocused Tumour Imaging Tumour In the Thyroid Image Cardiovascular Imaging Thyroid Imaging	Intravenous	In vivo model	Yes
Xe133-gas	Study on Lung Ventilation	Inhalation	In vivo model	Yes
Xe133 (isotonic solution sodium chloride)	Blood Flow to The Brain	Intravenous	In vivo model	Yes
Y90-Silicate	Rheumatic Diseases	Intra-articular	In vivo model	
Y90-Silicate	Malignant Condition	Intracavitary	In vivo model	

Table 1. List of Some Specific Radiopharmaceuticals [2]

VI. ADVANTAGES OF RADIOPHARMACEUTICALS IN HEALTHCARE SYSTEM

• It will provide immediate pain relief; • It can be used to diagnose and treat patients.
• Cancer is frequently curable.
• Is able to treat many disease sites.
• Widely available therapeutic options.
• Directly addresses cancer, especially beneficial for bone metastases.
• A single dose works for a select few patients.
Children may get testing using nuclear medicine.
• Nuclear medicine procedures are fully safe and have no negative effects.

VII. DISADVANTAGES OF RADIOPHARMACEUTICALS IN HEALTH CARE SYSTEM

• Patients will experience prolonged annoyance and discomfort once many portions are administered.
• Thyroid dysfunction, pituitary axis dysfunction, and vas complications are all linked to higher doses of head and neck radiation.
Pregnant women are not advised to undergo nuclear medicine examinations because unborn children are more sensitive to radiation than children or adults.
• Dental braces, permanent bridges, and tooth fillings could alter the area around the mouth.
• Some hypersensitivity will manifest.
• There is a risk of radiation.
• Myelosuppression may happen, especially if chemotherapy was administered beforehand.

VIII. STORAGE OF RADIOPHARMACEUTICAL SUBSTANCES

- Well-closed containers should be used to store radiopharmaceuticals.
- The storage circumstances ought to be such that they lower the maximum radiation dose rate to which a person is to be subjected to an allowable level.
- Precautions should be made to guard against ionizing radiation in accordance with national regulations.
- Glass vials, ampoules, or syringes must be sufficiently transparent to allow visual inspection of the contents for radiopharmaceutical preparations intended for parenteral use.
- Glass containers must discolor when exposed to radiation.

IX. LABELING OF RADIOPHARMACEUTICAL SUBSTANCES

The primary container's label includes:
- A declaration that the product is radioactive or the global radioactivity symbol
- The radiopharmaceutical preparation's name.
- Where applicable, that the product is intended for use in diagnosis or medicine.
- The administration path.
- For solutions, a statement of the radioactivity in a suitable volume (for example, in MBq per ml of the solution) may be substituted for the total radioactivity present at the provided date and time.
- The expiration date and the amount of time required should be labelled.
- The manufacturer's designated batch (lot) number needs to be stated.
- The entire volume for solutions.
- When necessary, a statement indicating no antimicrobial preservatives have been applied, together with the name and concentration of any microbial preservatives that have been added.

The label on the outside of the package reads:
- A notice indicating that the item is radioactive or the global radioactivity symbol.
- The radiopharmaceutical preparation's name.
- Where applicable, that the product is intended for use in diagnosis or medicine.
- The administration pathway.
- The total radioactivity present at a certain time and date; in the case of solutions, a statement of the radioactivity in appropriate volumes (for instance, in MBq per ml of the solution) may be substituted.
- The expiration date and the amount of time required should be labelled.
- The manufacturer's batch (lot) number must be provided.
- The entire volume for solutions.
- Any unique storage specifications, including light and temperature requirements. Wherever applicable, the name and concentration of any added microbial preservatives or, where necessary, that no antimicrobial preservative has been added.

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REFERENCE

[1]. Iverson (2007), "15.9.2 Radiopharmaceuticals", in Cheryl;.(eds.), AMA Manual of Style (10th ed.), Oxford, Oxfordshire: Oxford University Press, ISBN 978-0-19-517633-9.
[2]. http://www.moravek.com/characteristics-of-radiopharmaceuticals.
[3]. Schwochau, Klaus. Technetium. Wiley-VCH (2000). ISBN 3-527-29496-1
[4]. "Canada's Chalk River Reactor coming back online will not solve long-term isotope shortage in hospitals, researchers say".
[5]. "Archived copy" (PDF). Archived from the original (PDF) on 2018-03-13. Retrieved 2014-09-21.
[6]. Iverson, Cheryl, et al. (eds) (2007), "15.9.2 Radiopharmaceuticals", AMA Manual of Style (10th ed.), Oxford, Oxfordshire: Oxford University Press, ISBN 978-0-19-517633-9.
[7]. H.J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern Limited, edn. 4 (1995).
[8]. S.K. Saxena, M.Sc. Thesis, Studies on the Preparation and Characterization of 125I Medical Sources, Pune University, Pune, India (2004).
[9]. W.D. Ehman and D.E. Vance, Radiochemistry and Nuclear Methods
[10]. Weijia Z, Mcginity J. Influence of Eudragit® NE 30 D blended with Eudragit® L 30 D-55 on the release of phenylpropanolamine hydrochloride from coated pellets. Drug Dev Ind Pharm. 2003;29(3):357-66.
[11]. Rahman N, Yuen KH, Woei WJ. Formulation and evaluation of controlled release diltiazem pellets using Eudragit NE40. Acta Pharmaceutica Turcica. 2005;47(3):199-207.
[12]. Shivkumar HN, Desai BG, Sarasija S. Design and evaluation of pH sensitive multi-particulate systems for chronotherapeutic delivery of diltiazem hydrochloride. Ind J Pharm Sci. 2006;68(6):781-7.
[13]. Bendas ER, Ayres JW. Leaky enteric coating on ranitidine hydrochloride beads: Dissolution and prediction of plasma data. Eur J Pharm and Biopharmaceutics. 2008;69(3):977-85.
[14]. Wei J, Mingfeng Q, Xia S, Yungping Q, Mingming S. Preparation of slow-release pellets. Advances in Therapy. 2004;21(4):238-48.
[15]. Heng PW, Wang L, Tang E, Liew CV. Drying efficiency and particle movement in coating-impact on particle agglomeration and yield. Int J Pharm. 2008;350(12):172-80.