POSITRON-EMISSION TOMOGRAPHY (PET)--A NEW DIAGNOSTIC METHOD. PHYSICAL AND TECHNICAL REQUIREMENTS

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ABSTRACT

Positron emission tomography (PET) is an important modality in the field of molecular imaging, which is gradually impacting patient care by providing safe, fast, and reliable techniques that help to alter the course of patient care by revealing invasive, de facto procedures to be unnecessary or rendering them obsolete. Also, PET provides a key connection between the molecular mechanisms involved in the pathophysiology of disease and the according targeted therapies. Recently, PET imaging is also gaining ground in the field of drug delivery. Current drug delivery research is focused on developing novel drug delivery systems with emphasis on precise targeting, accurate dose delivery, and minimal toxicity in order to achieve maximum therapeutic efficacy. At the intersection between PET imaging and controlled drug delivery, interest has grown in combining both these paradigms into clinically effective formulations. PET image-guided drug delivery has great potential to revolutionize patient care by in vivo assessment of drug biodistribution and accumulation at the target site and real-time monitoring of the therapeutic outcome. The expected end point of this approach is to provide fundamental support for the optimization of innovative diagnostic and therapeutic strategies that could contribute to emerging concepts in the field of “personalized medicine”. This review focuses on the recent developments in PET image-guided drug delivery and discusses intriguing opportunities for future development. The preclinical data reported to date are quite promising, and it is evident that such strategies in cancer management hold promise for clinically translatable advances that can positively impact the overall diagnostic and therapeutic processes and result in enhanced quality of life for cancer patients.

Key words: (18)F-FDG; PET/CT; PET/MRI; positron emission tomography, annihilyatsiya

INTRODUCTION

Alternative methods of medical imaging include single-photon emission computed tomography (SPECT), X-ray tomography (CT), magnetic resonance tomography (MRI) and functional magnetic resonance tomography (fMRI), and ultrasound. SPECT is a PET-like imaging technique that uses radioligands to detect molecules in the body. SPECT is cheaper and provides lower image quality than PET.A positron emission tomography (PET) scan is an imaging test that can help reveal the metabolic or biochemical function of your tissues and organs. The PET scan uses a radioactive drug called a tracer to show both typical and atypical metabolic activity. A PET scan can often detect the atypical metabolism of the tracer in diseases before the disease shows up on other imaging tests, such as computerized tomography (CT) and magnetic resonance imaging (MRI).

Positron emission tomography (PET) is one of the most advanced imaging techniques in medicine, allowing the detection of the functional and metabolic activity of organs and tissues. PET scans are used to diagnose diseases, especially cancer, neurological disorders, and heart disease, at an early stage. PET scanning is a high-resolution technology that allows us to study biological processes in the human body at the molecular level.

The mechanism of action of PET

The use of radioactive tracer:

In preparation for a PET scan, a radioactive tracer is administered to the patient. This substance is used in conjunction with molecules that are actively involved in metabolic processes (e.g., glucose, water, oxygen). One of the most commonly used tracers is 18F-fluorodeoxyglucose (18F-FDG), which allows the monitoring of glucose metabolism.

Annihilation of the positron:

The tracer is converted into a positron (a positively charged electron) during radioactive decay. When a positron and an electron collide, annihilation occurs and gamma rays are emitted. These gamma rays are recorded by a PET scanner.

Detection of gamma rays by:

The PET scanner is equipped with special detectors to detect gamma rays. The gamma rays are scattered from different parts of the body to reach the detectors. These detectors detect the direction and energy of the gamma rays. The collected data is sent to a computer connected to the PET scanner.

Processing and creation of image

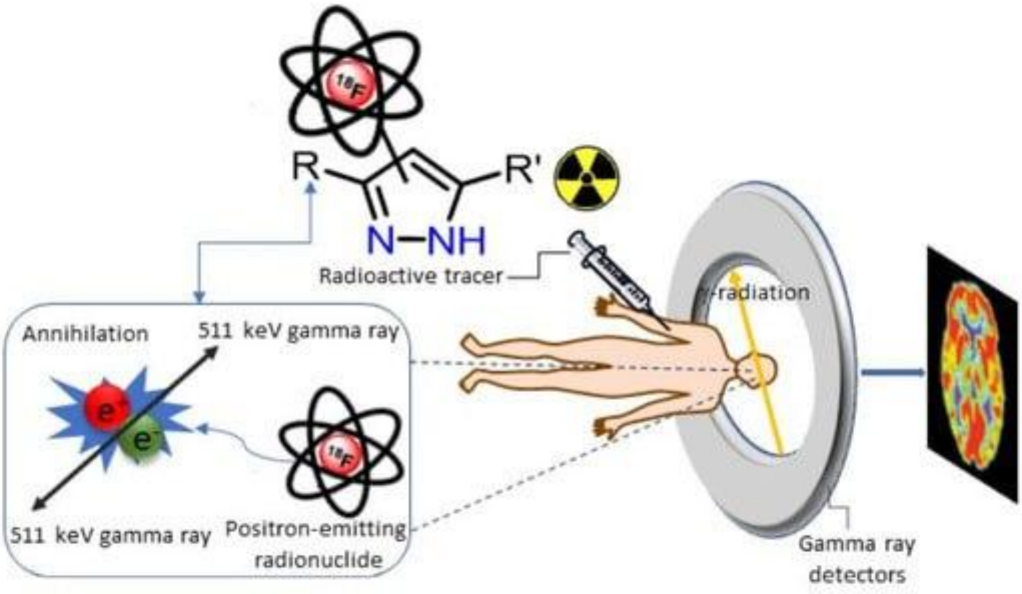
The computer then analyzes the gamma-ray data to create a three-dimensional (3D) functional image of the organs. This image shows a doctor

It tracks the metabolic activity of organs.

It determines the presence or absence of disease.

It assesses outbreaks, their rates, and their spread.

The images are highly accurate, enabling doctors to make timely diagnoses and develop effective treatment plans.



The main areas of application of PET imaging

Oncology (diagnosis of Saraton)

PET is effective in detecting cancer tumors, assessing their levels, and monitoring metastases.Since cancer cells typically have high metabolic activity, tracers accumulate in large amounts in these areas. PET provides accurate results in monitoring tumor size, spread, and response to treatment.

PET scans need to be interpreted carefully because noncancerous conditions can look like cancer. Also, some cancers cannot be seen on PET scans. Many types of solid tumors can be detected with PET-CT and PET-MRI scans, including:

The brain.
Breast.
The cervix.
Colorectal
Red wine.
Head and neck.
The lungs.
The lymphatic system.
The pancreas.
Prostate
The skin.

Without shields.

The use of positron emission tomography (PET) in neurology

Alzheimer's disease: PET can be used to detect a decrease in brain metabolism in the early stages of Alzheimer's disease. Alzheimer's-related changes are mostly seen in certain areas of the cerebral cortex (e.g., temporal and parietal regions). PET uses tracers that show a decrease in glucose metabolism, as well as amyloid beta plaques and tau proteins. This allows for a detailed study of the causes of the disease.

Parkinson's disease and other movement disorders: PET scans can be used to assess the activity of dopamine-producing neurons in Parkinson's disease. PET scans detect the state of dopamine receptors in the substantia nigra and can help identify dopamine deficiency. Parkinson's disease and other movement disorders are important in differentiating it from other movement disorders.

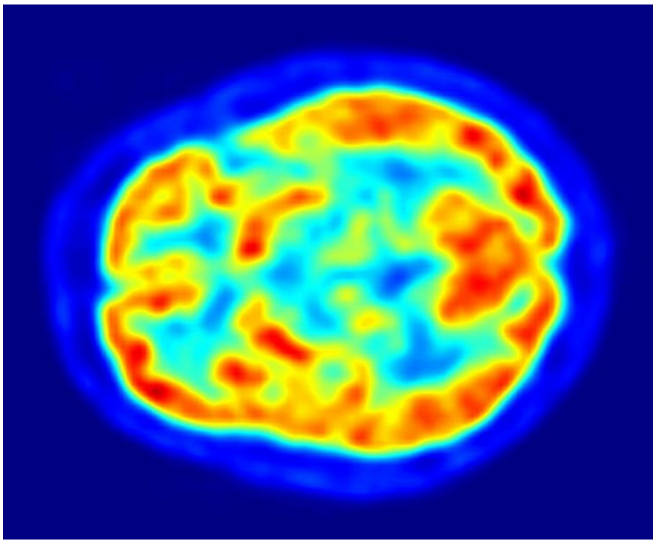
Epilepsy: PET scans are used to help identify the cause of epilepsy. Epileptic seizures are typically characterized by a decrease or change in metabolic activity. PET scans can detect these changes and help determine the need for surgery.

Diagnosis of brain tumors and tumors

PET is used to measure the metabolic activity of brain tumors. Cancer cells have a higher metabolic activity than healthy cells, which can be detected on PET scans. PET scans measure the rate of brain tumors, the extent of spread, and metastases. This is also used to monitor post-operative tumor regrowth.

Studies of brain activity

PET technology is widely used in research to study brain activity: the functional activity of brain regions, such as activity associated with thinking, memory, language, or emotional processes. Evaluation of neurotransmitter activity through PET in understanding psychological disorders (such as schizophrenia, depression, or bipolar disorder).



The use of positron emission tomography (PET) in cardiology

PET is used in cardiology to assess the metabolism, circulation, and function of heart tissue at the molecular level. The high sensitivity of PET helps to detect heart disease at an early stage and optimize treatment plans. The main areas of application are listed below:

Evaluation of the viability of the myocardium

PET scans can be used to determine the viability of the heart muscle (myocardium). After a myocardial infarction, some of the heart's tissues may be damaged by anemia, but they can still be repaired. PET scans detect cells that are alive but not active (in a state of hibernation). This information can help determine the need for surgery (such as coronary artery bypass grafting or angioplasty) to restore blood supply to the heart.

Determination of myocardial ischemia

PET technology allows the monitoring of the blood supply to the myocardium. It is highly effective in the detection of blood flow disorders such as ischemia, and it allows the molecular assessment of myocardial perfusion. Radioactive tracers (such as 13N-ammonium or 82Rb) monitor how blood is delivered to the heart muscle. This process, when used in conjunction with stress tests, provides clear results in the detection of ischemic seizures.

Detection of coronary artery disease

PET scans are used to assess the narrowing or blockage of coronary arteries. PET can be used to measure the amount and flow of blood reaching the heart muscle and to assess atherosclerotic plaques and their impact on the heart.

Analysis of the cardiometabolic processes

PET scans the energy and metabolic pathways of the heart muscle. Metabolic disorders can be studied by determining how heart cells use glucose or fatty acids. It's also used to detect heart disease associated with diabetes.

Diagnosis of cardiomyopathies

PET is used to analyze the metabolic activity and structural changes of heart muscle in various cardiomyopathies (e.g., dilated or hypertrophic). It can be used to detect inflammation or fibrosis.

Evaluation of the effectiveness of treatment of heart disease

PET technology is used to evaluate the effectiveness of various methods of treating the heart (e.g., surgery or drugs). For example, the recovery of heart muscle after coronary artery bypass grafting or angioplasty**.**

Application of positron emission tomography (PET) in pharmaceuticals and research

PET technology is used not only in diagnostics, but also in pharmaceuticals and scientific research. This technology is a powerful tool for evaluating the effects of drugs and understanding biological processes at the molecular level. Below are some of its applications in pharmaceuticals and research.

Development and testing of drugs

PET is used in the pharmaceutical industry to develop new drugs and study their mechanisms of action: The drug reaches its destination: PET is used to determine the distribution of drugs in the body and their concentration in tissues. Bioavailability assessment: This measures how well a drug is absorbed and metabolized in the body. Determination of dosage: Metabolic data from PET scans are used to determine optimal drug doses. Side effect studies: The effect of the drug on organs or tissues other than the target site is observed

The development of biomarkers

PET technology is used in the development of new biomarkers and their introduction into clinical practice: Biomarkers are used as diagnostic tools for early diagnosis and treatment of various diseases. PET assesses the correct functioning of biomarkers and their interactions with target molecules.

Neuropsychological research

PET is used in the field of neuroscience to study the effects of various drugs: the study of the activity of neurotransmitters (e.g., dopamine, serotonin). Understanding the mechanism of action of drugs used in diseases such as depression, schizophrenia, or Alzheimer's. The study of the effects of psychotropic drugs (such as antidepressants) on brain function.

Cancer research

PET technology is an important tool in the study of new approaches to cancer diagnosis and treatment: Immunotherapy and chemotherapy monitoring: PET monitors the effectiveness of treatment. Developing cancer biomarkers: Creating tracers that more accurately identify cancer cells. Optimizing radiotherapy: Identifying the affected area for radiotherapy using PET.

The study of metabolic processes

PET is used to study the major metabolic processes in the body: analysis of the metabolism of glucose, fatty acids, or oxygen in various organs and tissues. To determine how energy metabolism changes in different diseases (such as diabetes or cardiovascular disease).

Evaluation of the safety of medicinal substances

PET is used to test new drugs in the early stages of clinical trials: to see how a drug will react when injected into humans. It allows us to identify side effects and understand their molecular basis. PET is used to compare the results of animal models and human trials.

Development of individualized treatment

PET scans can be used to see how effective a drug is on different patients. It is used to tailor drugs based on genetic, biological, or metabolic differences. It helps develop accurate diagnostics and targeted treatment plans for a variety of diseases.

Development of radiopharmaceuticals

Tracers used in PET technology are an important area of scientific research in radiopharmaceutics: the development of new tracers and their assessment of their suitability for biological purposes. Improving the effectiveness of radiopharmaceuticals used for diagnosis and treatment.

Future Perspectives of PET Technology (PET) is a technology developed by

Positron emission tomography (PET) technology is currently an important part of medical diagnostics and is expected to be further developed in the future. Here are the prospects for PET technology:

1. Increase visual acuity

With new detector materials and algorithms, the signal detection accuracy can be significantly improved. This helps to detect smaller tumors and metabolic processes at low concentrations.

2. Expansion of hybrid systems

Other diagnostics combined with PET, such as PET/MRI or PET/CT, are becoming more widely used. These techniques allow for the study of a wide variety of diseases with high precision and help optimize therapy plans.

3. Development of designated radiotracers

The creation of new radioactive isotopes and targeted tracers expands the possibilities of detecting specific organs or disease processes. It's especially important to be clear about molecular targets for individualized therapy.

4. Artificial intelligence and data analytics

Artificial intelligence algorithms are used to analyze the PET data and interpret the results. This allows you to get results faster and more accurately.

5. Miniaturization and mobile technologies

Portable PET systems have evolved to enable onsite diagnostics. This can be especially important for rural areas and underserved areas.

CONCLUSION

Positron emission tomography (PET) is an innovative technology that provides high accuracy and reliability in diagnostic medicine. The main advantage of PET is its ability to detect changes at the molecular and cellular level, which can help diagnose diseases at an early stage. It's especially important in cancer, cardiovascular and neurological diseases.

PET technology has the potential to bridge the gap between diagnosis and treatment. The ability to monitor therapeutic efficacy and observe disease dynamics using innovative radioactive isotopes provides its widespread application. Integration with hybrid technologies (such as PET/CT and PET/MRI) also allows for simultaneous morphological and metabolic data acquisition.

In addition, the development of PET technology brings significant positive results in the following areas:

- Acceleration of the diagnostic process through artificial intelligence and automated data analysis.
- Developing an individualized treatment plan with the development of identified tracers.
- Expand diagnostic capabilities in underserved areas through miniaturization and portable systems.

In the future, PET technology will be used not only in clinical diagnostics, but also in research and pharmaceuticals. Improving its cost-effectiveness and making the technology available to the masses is an important step for the global healthcare system. PET technology will be a key tool in improving human health and in the detection of complex diseases.

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