Role of nuclear medicine in cancer therapy

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Abstract

Nuclear medicine is a multidisciplinary field that develops and uses instrumentation and tracers (radio pharmaceuticals) to study physiological processes and non-invasively diagnose, stage, and treat diseases. Particularly, it offers a unique means to study cancer biology in-vivo and to optimize cancer therapy for individual patients. A tracer is either a radio nuclide alone, such as iodine-131 or a radiolabel in a carrier molecule such as F-18 in fluoro deoxyglucose, or other feasible radio nuclide attached to a drug, a protein, or a peptide, which when introduced into the body, would accumulate in the tissue of interest. Nuclear medicine imaging, including single-photon emission computer tomography and positron emission tomography, can provide important quantitative and functional information about normal tissues or disease conditions, in contrast to conventional, anatomical imaging techniques such as ultra-sound, computed tomography, or magnetic resonance imaging. For treatment, tumor-targeting agents, conjugated with therapeutic radio nuclides, may be used to deposit lethal radiation at tumor sites. This review outlines the role of nuclear medicine in therapeutic treatment of cancer.

1 Introduction

Nuclear medicine therapy is a cancer treatment that uses radioactive drugs that bind to cancer cells and destroy them. This therapy is an option for some people with neuroendocrine tumors, prostate cancer, meningiomas, thyroid cancer and lymphoma. It has proved to be successful in easing symptoms, improving quality of life and extending life. Nuclear medicine therapy is an approach to treating cancer that might be used with or after other treatment options, such as chemotherapy and surgery. It won't usually lead to a cure unless combined with other therapies. But for many people it will control symptoms and shrink and stabilize the tumors, sometimes for years. Nuclear medicine therapy is sometimes the best option for people who no longer respond to other treatments.

What makes nuclear medicine therapy effective is the use of radioactive molecules as a drug (molecular radiotherapy). The drug recognizes tumor cells. It's injected intravenously, then circulates in the body, sticks to the tumor cells, delivers radiation directly and causes them to die. Some of the drug never attaches to cancer cells and keeps floating in the blood until the body gets rid of it, mostly in the urine. Over time, the radioactive drug stops giving off radioactivity and stops killing cancer cells. Nuclear medicine therapy is often repeated multiple times to achieve the most benefit.

Nuclear medicine therapy is also called peptide receptor radio-nuclide therapy (PRRT), targeted radiotherapy, radio-nuclide therapy, therapeutic nuclear medicine and a theranostic approach to treating cancer.

Nuclear medicine therapy uses radiopharmaceuticals targeting specific tumours, such as thyroid, lymphomas or bone metastases, delivering radiation to tumorous lesions as part of a therapeutic strategy to cure, mitigate or control the disease. It can be used either on selective targets or throughout the entire body.

Targeting the tumour :- The advancements in medical technology have led to a dramatic surge in the development and availability of new cancer treatments. The treatment of cancer involves different strategies, such as chemotherapy, surgery, radiation therapy and, most recently, targeted therapies, such as the use of radionuclide-based therapies employed in nuclear medicine. External radiotherapy with ionizing radiation is the most frequently employed radiation treatment of cancer patients. In this approach, the primary tumour and a limited area around it is treated through irradiation with high-energy X-rays.

Another treatment option available for certain types of cancer is the use of targeted radionuclide therapy, which is based on administering radioactive substances to patients. Just like chemotherapy, this therapy is a systemic treatment, reaching cells throughout the body by travelling through the bloodstream. However, unlike chemotherapy, these radioactive substances specifically target diseased cells, thus reducing potential side effects.

Radiopharmaceuticals :- The radiopharmaceuticals suited for therapeutic purposes are those that strongly bind with the tumour – also known as vehicles with a high tumour affinity. They can transport targeted doses of radiation directly to the tumours and its metastases, thereby sparing normal healthy tissue. The choice of the molecule that carries the radiation to the tumour is determined by its affinity – or binding power – to the tumour's target structures, such as antigens or receptors. The ionizing radiation emitted by radionuclides linked to the carrier kill cancer cells by damaging their DNA, causing the tumours to shrink.

An ideal radiopharmaceutical for therapeutic purposes should:

- act exclusively in the cells of malignant tumours;
- reach all the cells of malignant tumours wherever they are localized;
- leave healthy tissues and organs unhurt while bringing maximum doses of radiation to the tumour;
- eliminate malignant tumour cells with great effectiveness.

How the therapy works :- The biological action of a radiopharmaceutical is determined by the form of ionizing radiation emitted by the radionuclide. While imaging procedures in nuclear medicine require radionuclides that will emit (gamma) radiation able to penetrate the body, a different class of radionuclides possessing optimal relative biological effectiveness is needed for radionuclide therapy. The radionuclides best suited for tumour therapy are those emitting ionizing radiation with short penetration into the tissue, such as (alpha) or (beta) emitters, which release their energy in the proximity of their targets.