Medical applications of radiation and radioactive materials

Shortly after the discovery of X-rays by Wilhelm Roentgen in 1895, radioactivity was discovered by Henri Becquerel in 1896. These two events triggered a profound curiosity among mankind that would eventually lead to the development of medical applications of radiation and radioactive materials. After more than a century of devoted efforts by doctors, scientists, and engineers, radiation has become an important medical tool for the study, diagnosis, and treatment of various diseases, especially cancer.

Typically, there are three departments in a hospital that utilize radiation and radioactive materials. The radiology department uses external radiation beams for diagnostic purposes. The radiation oncology department uses external radiation or energetic particle beams to kill cancer cells and also uses internal sources of radiation to perform brachytherapy by placing sealed radioactive material directly inside or near a tumor to deliver a localized radiation dose over a short period of time. The nuclear medicine department administers radioactive materials into the body for diagnostic or treatment purposes.

Radiology

A modern radiology department uses radiographic X-rays, fluoroscopy, angiography, and computed tomography (CT), as well as non-ionizing radiation modalities such as ultrasound and magnetic resonance imaging (MRI).

The purpose of radiography is to view the internal structures of a human body. To create the image of an organ, a beam of X-rays is projected toward the object. The amount of X-rays absorbed is dependent on the particular density and composition of that object. The X-rays that pass through the object are measured with a detector behind the object. This information can then provide a superimposed two-dimensional representation of an object's composition.

A CT scan or CAT (computerized axial tomography) scan makes use of computer-processed combinations of X-ray images taken from different angles to produce cross-sectional images of specific areas of a scanned object, allowing the user to see inside the object without the need to cut it.

Radiation Oncology

Radiation oncology is also called radiotherapy. It is a branch of medicine that uses high-energy radiation from X-rays, gamma rays, neutrons, protons, and other sources to kill cancer cells and shrink tumors. Radiation may come from a machine outside the body (external beam radiation therapy), or it may come from a radioactive material placed in the body near cancer cells (internal radiation therapy). Systemic radiation therapy uses a radioactive substance, such as a radiolabeled monoclonal antibody, that travels in the blood to tissues throughout the body.

The most advanced, commercially available external beam cancer treatment machine is a cyclotron. A cyclotron is a charged particle accelerator, developed mainly for nuclear physics research. The major benefit of using proton beams from the cyclotron, compared to X-ray beam radiotherapy, is that the proton beams can be conformed and controlled more easily and precisely. The major drawback is that the cost of the cyclotron is extremely high. Therefore, cyclotron cancer treatment is only available in major medical centers.

Nuclear Medicine

This branch of medicine uses radioactive materials to provide information about the physiology of a specific organ or to treat disease. Nuclear medicine was initially developed in the 1950s by physicians with an endocrine emphasis, using the radioactive isotope iodine-131 to diagnose and treat thyroid disease.

A more recent development is Positron Emission Tomography (PET), which uses a positron-emitting radioactive material to detect the specific location and size of a tumor. The material is usually introduced into the body by injection: radioactive material is attached or absorbed in a nutrient, like sugar. Since cancer cells reproduce and grow faster than normal cells, the radioactive material accumulates faster, in larger quantities, in those cells. As the radioactive material decays, it emits positrons. A positron will combine with a nearby electron and result in a simultaneous emission of two gamma rays in opposite directions. The gamma rays are then detected by PET cameras and can give precise indication of their origins, readily identifying the location of many cancers.

Currently, the thyroid, bones, heart, liver and many other organs can be easily imaged to reveal dysfunction. In some cases, radioactive materials, or radiation in combination with special drugs, can be used to treat diseased organs or tumors.

Medial applications of radioactivity are advancing every day, and the benefits are improving human health across the country and around the world.