SEVEN THINGS TO KNOW ABOUT RADIOISOTOPES

1. What are radioisotopes?

Each atomic element knows exactly how many protons and neutrons it needs at its centre (nucleus) in order to be stable (stay in its elemental form). Radioisotopes are atomic elements that do not have the correct proton to neutron ratio to remain stable. With an unbalanced number of protons and neutrons, energy is given off by the atom in an attempt to become stable[1].

For example, a stable carbon atom has six protons and six neutrons. Whereas its unstable (and therefore radioactive) isotope carbon-14, has six protons and eight neutrons. Carbon-14 and all other unstable elements are called radioisotopes.

This movement towards stability, which involves emitting energy from the atom in the form of radiation, is known as radioactive decay.

This radiation can be tracked and measured, making radioisotopes very useful in industry, agriculture and medicine.

2. Where do radioisotopes come from? How are they made?

There are both naturally occurring and man-made radioisotopes. But for medical purposes, we only use the ones made by nuclear reactors and cyclotrons[2] because they are easy to produce, have the characteristics needed for imaging and typically have much shorter half-lives than their naturally occurring cousins.

Half-life is the amount of time it takes for half of the radioisotope to decay to half of its original activity, which tells us how long the radioisotope will remain. The very long half-lived radioisotopes are more stable and are therefore less radioactive. The half-lives of radioisotopes used in medicine range from a few minutes to a few days.

For example, rubidium-82, which is used for myocardial perfusion imaging has a half-life of 1.26 minutes, while iodine-131, used in thyroid treatment and diagnosis, has a half-life of eight days. Overall, there are about 1800 radioisotopes, and approximately 50 are being used in medicine.

[1]Stable isotopes exist as well, but they are beyond the scope of this article.

[2] A cyclotron is a complex machine that accelerates charged particles in a vacuum outwards from the centre along a spiral path. During the acceleration process, charged particles gain significant energy. The energized charged particles then interact with stable material that is placed in their path. The interaction transforms stable materials into medically useful radioisotopes that are used to make radiopharmaceuticals.

3. How do we use radioisotopes in medicine?

Some radioisotopes give off alpha or beta radiation, and these are used for treating diseases such as cancer.

Others give off gamma and/or positron radiation, which is used in conjunction with powerful medical scanners and cameras* to take images of processes and structures inside the body, and for disease diagnosis. Radioisotopes have various uses in hospital (clinical) settings. They are used to treat thyroid diseases and arthritis, to relieve arthritic pain and pain associated with bone cancer, and to treat liver tumours. In cancer brachytherapy, a form of internal radiation therapy, radioisotopes are used to treat prostate, breast, ocular and brain cancer. They are also effective for the diagnosis of coronary artery disease and heart muscle death.

In medicine, two of the most commonly used radioisotopes are technetium-99m and iodine-131. The gamma emitting technetium-99m is used to image the skeleton and heart muscle in particular, but also for imaging the brain, thyroid, lungs (perfusion and ventilation), liver, spleen, kidney (structure and filtration rate), gall bladder, bone marrow, salivary and lacrimal glands, heart blood pool, infection and numerous other specialized medical studies. Iodine-131 is widely used to treat over-functioning thyroid glands, thyroid cancer and in imaging the thyroid. It is a beta emitter, making it useful for therapy[3]. Radioisotopes are also used for medical research to study normal and abnormal functioning of organ systems. It can also help in drug development research.

***These powerful imaging devices include single photon emission computed tomography and positron emission tomography cameras, which are often used with computed tomography scanners and magnetic resonance imaging.**

[3]World Nuclear Association | Radioisotopes in Medicine www.world-nuclear.org/info/Non-Power-Nuclear-Applications/Radioisotopes/Radioisotopes-in-Medicine

4. Why do we use radioisotopes in medicine? What's so special about them?

Radioisotopes are special because certain organs in the body respond in unique ways to different substances. For example, the thyroid absorbs iodine, more so than any other chemical, so the radioisotope iodine-131 is widely used to treat thyroid cancer and in imaging the thyroid. Similarly, specific radioactive chemicals are picked up and metabolized by other organs like the liver, kidney and brain. But most radioisotopes need to piggyback on something else (a biologically active molecule) to get to the desired organ. For example, technetium-99m is often tagged to six methoxyisobutylisonitrile molecules to get to heart tissues for the diagnosis of cardiac disorders.

Formulations of radioisotopes tagged molecules (called radiopharma-ceuticals) are inhaled, ingested or injected to help physicians measure organ size and function, identify abnormalities, and target treatment to a particular area.

Radioisotopes are also special because their use provides patients and doctors with the option of using minimally-invasive surgical techniques, rather than the far more risky large-scale surgeries, from which it is harder to recover, that were used in the past to treat most conditions. Radioisotopes allow targeted treatment to all visible and invisible sites of disease in the body.

5. Are radioisotopes dangerous to patients?

The radioisotopes given to patients under-going diagnosis or treatment decay and quickly become stable (non-radioactive) elements within minutes or hours depending on their half-lives or they are rapidly eliminated from the body.

Doctors choose to use radioisotopes that have the appropriate half-lives and energy in order to get the best treatment, diagnosis or information possible without any harm to normal organ tissue. For example, technetium-99m has a half-life of six hours and gives off 140 keV (kiloelectronvolts) of energy, which is quite low and not enough to harm patients.

Doctors are also very careful about the amount of radioisotopes given to patients to minimize radiation dose while ensuring images of acceptable quality.

Short-lived and very short-lived radioisotopes are used in order to minimize the already small radiation dose the patient receives from the use of radiopharmaceuticals.

6. Are radioisotopes inside a patient dangerous to the public?

Medical staff follow strict rules and are trained to ensure that those patients who are given therapeutic doses of radioisotopes (these are only used for cancer treatment and other kinds of therapy, **never** for diagnosis) are kept isolated in their hospital rooms until the patient's exposure to the worker and public is reduced to a safe level. The nurses, doctors and porters charged with their care also maintain a safe distance during any interaction and wear personal dosimeters that keep track of their radiation doses at work to ensure that their doses do not exceed a specified limit, which is far below the safety threshold.

As soon as the radioisotopes decay to a level where the radiation exposure is low enough, the patients are free to go about their normal lives and return to their normal routines.

7. If medical staff are cautioned to keep a distance, then why are these treatments allowed for patients?

Patients benefit from the properties of radiation in the treatment of cancer. Those who need the procedure are justified in having the procedure. It all relates to 'justification', a key concept in nuclear medicine. Justification means that the benefit derived from the use of radiation must outweigh the potential harm to the patient. And for someone who has cancer, the use of a short lived radioisotope during treatment could cure them from the cancer or extend their lives. Health care workers are trained on clinical practices to appropriately manage exposure as they provide support for patients undergoing radiation therapy. Therefore these treatments are often justified in the eyes of both the patient and their physician.

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