Medical Miracles

Isotopes in Nuclear Medicine

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Medical Miracles: Isotopes in Nuclear Medicine

Can a simple word have both a positive and negative connotation? "Nuclear" certainly does. For some, that three syllable word brings with it painful memories of wars long past and wounds gently stitched. And yet for others, their very being depends upon such a small thing. But is it really so small? Nuclear medicine has greatly impacted society in ways many fail to realize. The radiation and treatments account for ninety percent of all procedures used for diagnosis in over 10,000 hospitals worldwide, helping to save countless lives from cancer and other harmful diseases each day (World Nuclear). But while the acceptance of isotopes in nuclear medicine has reached a new high, the struggle to maintain a supply of these isotopes has begun to slide below adequate.

The isotopes used in nuclear medicine may be categorized into one of two classes: stable and unstable. Stable isotopes do not experience radioactive decay, and are most commonly used in the diagnosis of disease, understanding metabolic pathways in humans, and answering fundamental questions of nature. There are 82 stable elements and about 275 stable isotopes of these elements (Nuclear Medicine). Examples of these stable isotopes are carbon-13, nitrogen-15, and oxygen-18, which are derived from their parent elements. Isotopes have the same atomic number, or number of protons, as their parent element. However, these isotopes differ in the number of neutrons each element contains (Physics).

Diagnostic radiopharmaceuticals are a number of chemicals that are absorbed by specific organs, learning to attach various radioisotopes to biologically active substances. The thyroid attracts iodine, hence the use of iodine-131 when treating thyroid cancers. In addition, scientists have discovered exceptional advancements of the brain using glucose. These radiopharmaceuticals can be used to examine the blood flow to the brain, functionality of the liver, kidneys, lungs, or heart, and assess bone growth and complete other diagnostic procedures. Another important use includes the prediction of the effects of surgery and assessment of changes since treatment. This non-invasive technique has become a powerful tool, especially with the PET scans becoming more widely available (World Nuclear).

In order to be effective, radioisotopes must emit gamma rays with enough energy to escape the body but have a half-life with the capability to decay soon after the completion of a test or imaging. An artificially-made radioisotope, technetium-99 is produced mainly as a by-product from nuclear reactors and is the most common radioisotope in nuclear medicine. Medical institutions use molybdenum / technetium reactors as a source for their supply of Tc-99 (EPA). As technetium-99 is used in about eighty percent of all nuclear medicine procedures worldwide, the isotope plays a vital role in the advancement of the practice. Principally, technetium-99 is used for diagnosis and treatment, most notably in the kidneys, heart, lungs, liver, spleen, bone, and blood flow. And as the technetium-99, typically generated from molybdenum-99, contains a half-life of just six hours, the isotope is used constantly in imaging tests, such as Myocardial Perfusion Imaging (MPI). The MPI is important for the detection and prognosis of coronary artery diseases, heart muscle death, and the location of low-grade lymphomas (World Nuclear)

Radioisotopes are also used to label molecules of biological samples outside of the body. Pathologists have developed countless ways to test the constituents of blood, serum, urine, hormones, antigens, and many other drugs by means of these radioisotopes. Oftentimes, a radioimmunoassay is used. This is a sensitive method for measuring small amounts of substances in the blood. The radioisotopes are mixed with antibodies and inserted into a blood sample from a patient, eventually allowing physicians to measure the quantity of the substance. First introduced in 1959 by Americans Rosalyn Yalow and Solomon Berson, radioisotopic techniques are now used throughout the world on a daily basis.

Also making an appearance in the world of nuclear medicine is rubidium-82, which is generated from strontium-82. This isotope is most prevalent in Position Emission Imaging (PET). Rubidium-82 is one of many products formed by cyclotrons. With its main clinical role in oncology, radioactive rubidium-82 has a half-life of less than 1.5 minutes and decays by position emission (American Heritage). As the 2015 year progresses, more and more people are being diagnosed with a form of cancer. In the United States alone, a projected 1.6 million will contract a cancerous disease within the year and almost 600,000 will die of these diseases (Cancer Facts).

Unfortunately, maintaining an adequate supply of these isotopes is more difficult than it may seem. As the United States does not have the means to produce these isotopes, reliance upon Europe and the rest of the world is heavy, especially for molybdenum-99. To reduce this dependence, the United States has begun development for its own domestic production of molybdenum-99 using non-highly enriched uranium, both reactor and non-reactor. The first of several new commercial projects in the United States is expected to be completed in the next two to three years. But for now, although the United States is nursing two generators, they do not have the capability to produce the molybdenum-99, and are instead able to convert the isotope to the much needed technetium-99. Because many of the world's production plants are scheduled to shut down within the next five years, first-world countries are panicking to find other manufacturing ideas.

In June 2011, the High-Level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) released a policy approach to regulate a sustainable economic basis and provide for a stable supply of medical isotopes. Introducing six principles, the HLG-MR addressed fundamental problems that threaten the reliable global supply of molybdenum-99 and technetium-99. Due to market failures, the supply of these isotopes has greatly decreased, causing the group to also introduce the "four pillars of reform": 1) Improvement of market economics in the molybdenum-99 and technetium-99 supply chain is needed. 2) Structural changes are necessary. 3) Governmental positions on the production of these isotopes must be clearly defined. 4) An effective and coordinated international approach is necessary. Because the United States accounts for almost one half of the world's overall demand for molybdenum-99, these "pillars" need to be taken into consideration to provide for a secure supply of key isotopes (High-Level Group). Without one, the United States and world will soon find themselves milking the few producers of whatever the generators have left, with the hope that one day the supply will once again be in surplus.

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