The critical role of radioisotopes in healthcare

In the public mind, the word "nuclear" usually conjures up associations with either power plants or bombs. Yet the application of nuclear technology also plays a critical role in health care. Over 200 different radioisotopes are used in millions of diagnostic and treatment procedures every year.

Some of the more common radioisotopes used for medical applications include:

- Technitium-99m (Tc-99m) as a radioactive tracer in a variety of medical nuclear imaging processes. Tc-99m is a decay product of molybdenum-99 (Mo-99), and is produced in nuclear reactors. It's the most commonly used radioisotope.
- Nitrogen-13, Carbon-11, and Fluorine-18 for positron emission tomography (PET) imaging. These radioisotopes are produced in cyclotrons.
- Yttrium-90 for treating non-Hodgkin's lymphoma. It occurs naturally as a rare earth element.
- Iodine-123 for thyroid imaging. It's produced in cyclotrons.
- Iodine-131 for treating thyroid cancer. It's produced in nuclear reactors, and was the first radiopharmaceutical employed going back to 1946.
- Indium-111 as a radioactive tracer for specialized imaging diagnostic tests. It's produced in cyclotrons.

Approximately 90 percent of medical radioisotopes used in this country are imported from Canada and Europe. About 70 percent of American radio-medicine procedures use Tc-99m. All of this key radioisotope is imported, with the majority coming from the National Research Universal (NRU) reactor located at Chalk River in Ontario, Canada. The NRU, however, is slated for shutdown in March 2018.

Two Multipurpose Applied Physics Lattice Experiment (MAPLE) reactors were built in Canada to replace the aging NRU. The 10-megawatt MAPLE reactors were designed for the single purpose of manufacturing medical radioisotopes. MAPLE I went critical in 2000 and MAPLE II in 2003, but the program was terminated by the Atomic Energy of Canada Limited in 2008 due to unresolved technical issues.

Timing is critical in the use of Tc-99m. Tc-99m is a daughter product of Mo-99. Mo-99 decays with a short half-life of 2.75 days, and the half-life of Tc-99m is even shorter – a mere 6 hours. The Mo-99 is shipped to hospitals and other medical facilities in "technetium-99m generators," otherwise known as "moly cows." The Tc-99m is chemically extracted at the point of use as a decay product from the Mo-99.

For these reasons, the need for reliable domestic production within the United States is imperative. According to the National Research Council and Institute of Medicine, "a dedicated radionuclide production facility is urgently needed to foster and facilitate research and training in the use of radionuclides in the biosciences and to provide a domestic, year-round continuous supply of radionuclides for nuclear medicine practice."

Several companies in the U.S. are racing against the March 2018 deadline to come to market with American produced Mo-99/Tc-99m.

In addition, the National Nuclear Security Administration (NNSA) is subsidizing two of these companies, SHINE Medical Technologies and NorthStar Medical Radioisotopes. According to the NNSA, these multi-million-dollar awards will help "accelerate the establishment of new, domestic sources of the medical isotope molybdenum-99 (Mo-99) produced without the use of proliferation-sensitive highly enriched uranium (HEU)."

The NNSA has 50 percent cost share agreements with both SHINE and NorthStar, up to a total funding level of $25 million for each company.

The SHINE (Subcritical Hybrid Intense Neutron Emitter) project relies on particle accelerator technology and will be built in Janesville, Wisconsin. The Nuclear Regulatory Commission approved the construction permit for this first-of-a-kind production facility this past February.

NorthStar will use the University of Missouri Research Reactor for commercial Mo-99 production, and is developing both neutron capture and accelerator-based technologies.

Other companies are also looking to enter this lucrative market. If these efforts are successful, then the United States will become self-sufficient in the production of the most common medical radioisotope. In reality, it's a race of life or death.