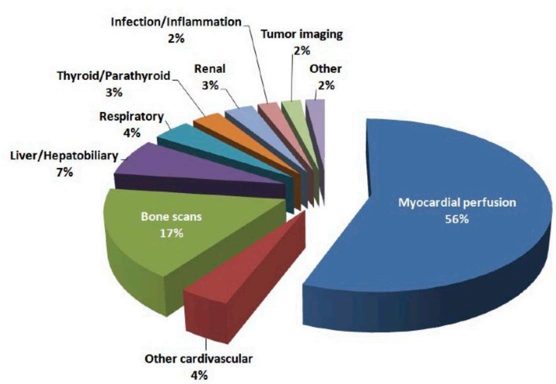
In the past three years, medical isotopes have been in the news as aging of nuclear reactors threaten global supplies. The isotope in question is Technetium-99m, used in about 80 per cent of medical diagnostic imaging procedures worldwide. Yet ninety-five per cent of the world's supply is produced at only five nuclear reactors; in Canada, Belgium, France, the Netherlands, and in South Africa. As the National Research Universal (NRU) reactor in Chalk River, Ontario, faces final shutdown in 2016, Canada is searching for alternatives to reactor-based isotope production. The federal government will shortly announce the allocation of $35 million in funds through the Non-reactor based Isotope Supply Contribution Project (NISP) to develop non-reactor based technologies for the production of medical isotopes.

Uses of Technetium-99m

Technetium-99m is a radioisotope used in about 24 million medical imaging procedures worldwide each year. Isotopes are injected into a patient's body, and detected via cameras such as Single Photon Emission Computed Tomography (SPECT) cameras, that detect gamma rays emitted by the decaying isotopes. Many organs and systems can be imaged by injecting, ingesting, or inhaling a substance tagged with Tc-99m. For example, Tc-99m-methoxyisobutylisonitrile (MIBI) can detect abnormal blood flow to the heart. Tc-99m tagged to white blood cells can detect hidden abscesses.



Sources: IMV 2007 Nuclear Medicine Market Summary Report, October 2007, Burns 2007, SECOR Analysis

Fig. 1.1: Uses of Technetium-99m in medical imaging: a breakdown of the medical images that can be produced. (Goodhand et al., 2010; to use this image please call 613-992-4447) and/or email (media@nrcan.gc.ca)**)**

Tc-99m's short half-life (six hours) minimizes radiation exposure to the patient, and it produces an easily detectable gamma ray. Unfortunately, this half-life means that it can't be stockpiled. To ensure that Tc-99m is available around the world, its parent isotope, Molybdenum-99, is produced and shipped.

How we get Tc-99m – the supply chain in Canada

Highly enriched uranium-235 is imported from the United States to the National Research Universal (NRU) reactor in Chalk River, Ontario. In the reactor, U235 is split into daughter products, 6 per cent of which is Mo-99. The half-life of Mo-99 is 66 hours, and so the product must be shipped rapidly.

The half-life of an isotope measures the time for half of a sample of the parent molecule to decay to daughter isotopes. In this case, given a sample of Mo-99, after 66 hours, half of that sample will have decayed to Tc-99m.

Mo-99 is quickly shipped to processing plants for purification. In Canada, this occurs at MDS Nordion in Kanata, about two hours southeast of Chalk River. After processing, which takes as little as two to six hours, Mo-99 is shipped to the U.S, where Tc-99m-generators extract the decayed daughter Tc-99m isotopes from the parent Mo-99. The isotopes are then shipped on to final destinations in North and South America, Asia, and Europe.

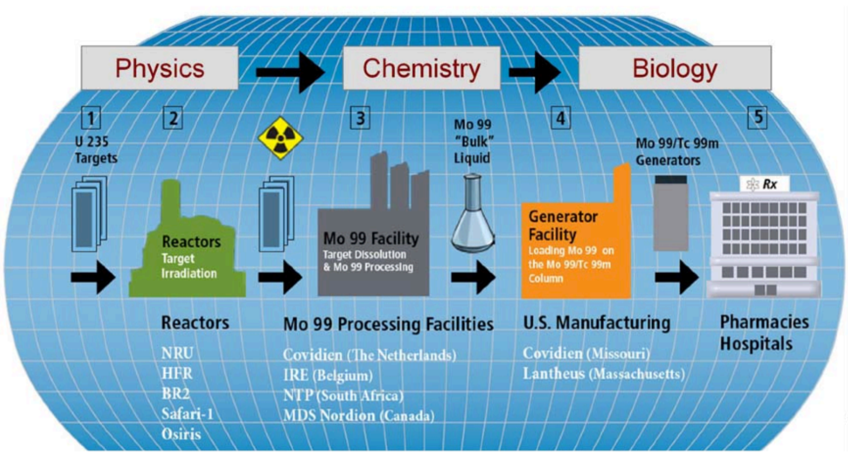


Fig. 1.2: The current production model (TRIUMF) **(You are free to use this image in your stories).**

Issues with the current supply chain

In addition to safety issues with the aging reactors, all the reactors that currently produce Tc-99m use highly enriched, weapons-grade uranium. To reduce security risk, Canada has committed to finding safer methods of production. The United States has announced that they will be decreasing or ceasing export of weapons-grade uranium between 2016 and 2019. The manufacture of isotopes also produces nuclear waste, which needs to be disposed of and monitored.

Canadian technology competes for NISP grants

During the recent medical isotope crisis, Ottawa decided to allocate funds to the development of new technologies in Canada for producing isotopes. Instead of using nuclear reactors, NISP requested proposals that utilize one of two particle accelerator technologies: cyclotrons, or linear accelerators. Groups that already manufacture and use these technologies are established in Canada; at TRIUMF in Vancouver, or at Atomic Energy of Canada Laboratories in Winnipeg and Ottawa. At least four groups have proposed partial solutions, and hope to obtain full or partial funding. Some of these proposals use Mo-100, a naturally occurring isotope of Molybdenum, eliminating the need for uranium.

Cyclotron technology

Several groups propose that the hospitals manufacture their Tc-99m directly using small cyclotrons. Some Canadian hospitals already have such cyclotrons that manufacture other medical isotopes. The University Hospital of Sherbrooke recently showed that these machines can also manufacture Tc-99m.These circular accelerators direct protons at Mo-100 to transform them to Tc-99m.

Linear accelerator technology

At least two other groups propose transforming Mo-100 into Mo-99 with linear accelerators that use beams of electrons. A TRIUMF-CNRC-Mevex group suggests distributing linear accelerators to hospitals, who would manufacture and use Tc-99m directly. In another plan, the consortium of Acsion and the University of Manitoba uses a linear accelerator to irradiate molybdenum to produce Mo-99 for distribution to hospitals, where the final extraction of Tc-99m would be done.

FYI: Other medical isotope technologies

Positron Emission Tomography (PET) scans use other radioisotopes for imaging. The most common isotope is Fluorine-18, which emits a positron as it decays that's detected by the PET machine. There are 31 PET machines in Canada, 15 in Quebec. Each machine needs to be near a cyclotron that can produce F-18. While PET scans are faster, more detailed, and give similar or lower does of radiation to patients, they're more expensive than scans using Tc-99m.

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