

THE GLOBE AND MAIL 

Advanced Cyclotron Systems's TR24 cyclotron is delivered to Sherbrooke University's clinical research centre.

Courtesy of CHUS

DISCOVERIES

Radioactive medicine without the nuclear headache

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A made-in-Canada solution to our medical-isotope problem could come from a machine with a name that could have been pulled straight from the pages of a science fiction novel: the cyclotron.

“It was really pooh-poohed, this idea of using cyclotrons; they said there was no way we could produce enough in a commercially meaningful way,” says John Wilson, the cyclotron facilities manager at the University of Alberta’s Cross Cancer Institute.

In mid-2010, scientists at the University of Sherbrooke and the University of Alberta made technetium-99m, the most commonly used medical isotope, without a nuclear reactor. Last fall, the Alberta scientists began putting the cyclotron-produced technetium-99m through its paces, testing it in animals and humans, and found that the medical scans looked the same as those done using the regular stuff.

Now they're looking to make more of it using more powerful machines, to prove that a cross-country cyclotron network could meet most of Canada's medical isotope needs. Success could lift the country from its dependency on the aging reactor at the Chalk River Laboratories near Ottawa.

Last week, the University of Sherbrooke received a higher-current cyclotron from Advanced Cyclotron Systems Inc., a company based in Richmond, B.C. The University of Alberta will install the same model in an old curling club on its south campus by the end of March.

"Cyclotrons are a novel and very exciting way of producing technetium-99m," says Kevin Tracey, vice-president of the Ontario Association of Nuclear Medicine and the medical director of nuclear medicine at Hôtel-Dieu Grace Hospital in Windsor.

"There remain some technical impediments to making it efficient in day-to-day operations, but if we can produce it close to home, in our communities, that is a much better solution," he says.

Technetium-99m is the most common medical isotope used in the practice of nuclear medicine. About 80 per cent of all medical radioisotope tests—from cardiac perfusion tests to bone scans for cancer—require technetium-99m. In Canada, it's used in roughly 1.8 million procedures annually.

But there's almost no natural technetium-99m on Earth. Instead it is produced via a precursor called molybdenum-99 that must be made in a nuclear reactor from highly enriched uranium.

Molybdenum-99, or "moly-99", is an unstable isotope without much use in nuclear medicine. But it does decay into the sought-after technetium-99m, so under current technology, it is extracted from a nuclear reactor, purified and shipped out to hospitals in lead containers called generators. The short half-lives of moly-99 (66 hours) and technetium-99m (6 hours) mean that neither isotope can be stockpiled.

About 40 per cent of the global supply of moly-99 comes from the aging Chalk River reactor. In 2007, an unexpectedly long reactor shutdown caused a technetium-99m shortage around the world. It happened again two years later. Although the reactor is back online today, its operating license will expire in 2016.

Ottawa has invested some \$35-million to encourage research to produce an alternative source, including the projects at Sherbrooke and Alberta.

"We have to find a way to continue to produce technetium-99m for Canadians and, ultimately, the international environment," says Sandy McEwan, chair of the oncology department at the University of Alberta.

The cyclotron is a large electromagnet that looks a little like an Oreo cookie. But instead of chocolate biscuits, the cyclotron has electromagnets, and in the place of a sweet filling, there are electrodes that accelerate a stream of charged particles to extreme speeds in a continuous spiral.

The process of transforming moly-100 into technetium-99m begins by setting up a quarter-sized disc of moly-100 as the target. Hydrogen atoms sporting an extra electron stream into the core of the cyclotron where they start to circle, alternatively attracted and repelled by the forces created by the electromagnets.

The particles pick up speed with each rotation and begin to drift outward, until they near the outermost edge, travelling at close to 20 per cent of the speed of light—about 60,000 kilometres per second—fast enough to take you around the Earth 1.5 times in a second. Then the particles are stripped of their electrons and spat out in an intense proton beam that passes through the moly-100 target. Some of the protons will hit the nucleus of a moly-100 atom, blowing off two subatomic particles called neutrons, and transform it into technetium-99m.

The approach offers some added perks: Cyclotrons can be used to produce tracers for other nuclear medicine

procedures, including PET scans, which are expected to increase in the future. Moly-100 is a naturally occurring isotope mined in several parts of the world, and the moly-100 target can be recycled and reused.

If the teams are successful, each cyclotron could produce more than enough technetium-99m for its region. "Everything is going well right now, I'm optimistic," says Brigitte Guérin, a research director at Sherbrooke, who says that with the new machine, two runs of six hours each would produce 800 doses of technetium-99m per day, and meet the needs of a population of 6 million.

"The biggest challenge right now is whether the cyclotron technology is robust and reliable enough to do this on a daily production basis," says Dr. McEwan. He hopes they'll have the answer by year-end.

"With 15 to 16 of these cyclotrons spread out across the country, we can supply 95 per cent of the population with all the technetium-99m needed," he adds. "And investing in cyclotrons now will mean hospitals can meet the need for PET isotopes in the next five to 20 years."

Special to The Globe and Mail

Good to know

- 50 million nuclear medical body scans are performed each year around the world.
- 80% of these procedures use Technetium 99.
- The ACSI TR24 cyclotron can accelerate particles at about a quarter of the speed of light.
- *Source: Advanced Cyclotron Systems Inc.*

Medical procedures using Tc-99m

Myocardial perfusion - 56%

Bone scans - 17%

Other cardiovascular - 4%

Liver/Hepatobiliary - 7%

Respiratory - 4%

Thyroid/Parathyroid - 3%

Renal - 3%

Infection/inflammation - 2%

Tumor imaging - 2%

Other - 2%

Source: IMV 2007 Nuclear Medicine Market Summary Report, SECOR Analysis