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Cyclotron production of medical isotopes scales up

Five years after a cranky old nuclear reactor put Canada's medical community on notice that its supply of a key radioisotope was no longer secure, investigators have declared an entirely different source ready for prime time. Cyclotrons, which were once relatively obscure pieces of lab research equipment, are poised to displace the reactor as Canada's optimal source of technetium 99, the radioactive staple of modern medicine.

Some 30 hospitals across the country house cyclotrons, known popularly as "atom smashers." They look like a metal box about the size of a single car garage, but inside, powerful magnetic fields accelerate charged particles to high energies, then aim them at a target. The target contains one of numerous types of materials, which is then transformed into a radioactive compound.

In this way, molybdenum can be transformed directly into technetium 99, the workhorse isotope used in SPECT (single photon emission computed tomography), which creates scans for tens of millions of patients around the world every year. On June 9, a team in Vancouver, British Columbia demonstrated how a single cyclotron operated by the BC Cancer Agency can produce enough technetium to meet the SPECT needs of the Vancouver metropolitan area.

"It was surprisingly simple," says Francois Benard, one of the research team's principal investigators, who holds a research chair in functional cancer imaging at the cancer agency. "We really feel we have a good understanding of the issues and a good solution in the works to make this a viable process."

The team works closely with the Lawson Health Research Institute in London, Ontario, the Centre for Probe Development and Commercialization in Hamilton, Ont., and TRIUMF, a national physics research laboratory in Vancouver.

Previously, at least half of the world's supply of technetium 99 was chemically generated at medical centres that used molybdenum irradiated in a single nuclear reactor: Atomic Energy of Canada Limited's facility in Chalk River, Ont. When this 50-year-old reactor unexpectedly went off-line in 2008, many of these same centres ran short of isotopes for SPECT scans, and patients had their procedures cancelled or delayed. The ensuing public outcry prompted the Canadian government to look for ways to shore up the supply chain.

Hospital cyclotrons have long been able to produce modest amounts of technetium for laboratory purposes, but now it has been shown that this same capability can be augmented to deliver technetium in amounts that could serve large parts of the country.

"We know we can make it reliably. And we're still working on the final model of how this would be implemented," says Benard.

Paul Schaffer, head of TRIUMF's Nuclear Medicine Division, believes the scale-up will continue. "We can supply British Columbia with the infrastructure that we have in place already," he says.

Natural Resources Canada has invested almost $60 million to encourage research teams — including Benard's — to find ways of producing the isotope without investing

in new equipment. Cyclotrons in hospitals across Canada are a real contender.

This summer, Edmonton is launching a new cyclotron that is larger than its existing one at the Cross Cancer Institute. According to John Wilson, who manages the Edmonton PET Centre, the two devices should readily meet all the technetium needs of Alberta.

"With seven or eight of these across the country, we could produce 90% of the needs of Canada," he says.

This emerging Canadian model has attracted the attention of observers in other countries who are worried about their dependence on technetium from aging reactors, Wilson adds. "It's gone from the Europeans two or three years ago saying 'Don't, this is impossible, this won't work' to where they are very interested now. They realize it will work."

Progress has also been made on a cyclotron pair in Quebec, at the Centre Hospitalier Universitaire de Sherbrooke–Hôpital Fleurimont. Eric Turcotte, a clinician-researcher there who has been on the front lines of this issue since the Chalk River reactor breakdown, can foresee how just a few of these machines could meet the province's technetium needs.

In the meantime, Turcotte and other researchers anticipate the challenge of meeting Health Canada Good Manufacturing Practice regulations.

Administrators at the various cyclotron facilities are already coming to grips with this challenge, which will be essential to ensuring patients can take advantage of the new supply of technetium. And since the Chalk River reactor is officially set to get out of this business by 2016, people like Schaffer are not yet ready to relax and count their isotopes.

"We've got to keep our nose to the grindstone," he says. — Tim Lougheed, Ottawa, Ont.

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