Accelerator Production of Tritium as a Future Source of Medical Radionuclides

A 6-month study conducted by the Medical University of South Carolina and the University of South Carolina (Spicer KM, Baron S, Frey GD, et al. *Evaluation of medical radionuclide production with the accelerator production of tritium [APT] facility*) and a workshop held in Augusta, Georgia, November 9–10, 1997, by the Medical University of South Carolina concluded that a domestic source for medical isotope production is needed and that the APT could also produce medical nuclides for both research and nuclear medicine applications.

Speakers at the workshop, which welcomed 85 attendees, included nuclear medicine physicians, physicists, pharmacists, pharmaceutical firm representatives, government officials and APT designers. The conference determined that there is a substantial need for a U.S. source of medical nuclides and that many nuclides needed for medicine and research should be produced in larger quantities.

In particular, the study and workshop concluded that the APT could produce a variety of radionuclides for diagnostic, therapeutic and research use. Major motivating factors for medical radionuclide production with the APT are the aging of existing U.S. production facilities and the increasing reliance on nondomestic suppliers. Technetium-99m, the most frequently used radionuclide, is supplied to the U.S. by a single foreign company with a 40-year old reactor (see "Commentary: Investing in the Future," p. 19N). In addition, many nuclides are desired for research or for use in treatment and diagnosis but either are not available or are exorbitantly priced due to short supply. APT capabilities for radionuclide production are such that it could comfortably meet present market needs as well as adapt to future market demands.

The APT, the largest accelerator ever constructed, would be a unique asset to the U.S. and would have as an added advantage the ability to produce medical nuclides as a complement to its primary mission. A gigawatt accelerator offers distinct advantages over both reactors and existing accelerators. The neutron flux produced in the largest blanket assembly is close to that present in reactors. In addition, the accelerator's proton beam will be of extremely high current (100 mA) and energy (1.7 GeV) compared to accelerators currently available for nuclide production. This could enable the APT to produce a variety of nuclides in quantities significantly above what is available with existing accelerators. Radionuclides could be produced by inserting targets for irradiation in the neutron flux of the target/blanket assembly or by diverting a small fraction of the proton packets from the beam. Significantly, the necessary production rates for either method of nuclide production would have a very small effect on tritium production rates or reliability. Some of the longer-lived nuclides could be obtained as byproducts of normal operation of the target assembly without affecting tritium production.

Molybdenum-99, which is dominant in the medical radionuclide market, could be produced with either proton or neutron reactions. Other high-demand radionuclides, including ^{60}Co, ^{89}Sr, ^{131}I, and ^{201}Tl, could also be produced. Perhaps more significant, however, is that APT production capability has the potential to supply many radionuclides that are now available only in limited quantities and at very high cost (e.g., ^{81}Rb, ^{82}Sr, ^{111}In, ^{123}I and ^{127}Xe). Other radionuclides with new and promising applications critical for improved diagnosis and therapy include ^{47}Sc, ^{103}Pd and ^{153}Sm. The APT facility design has the flexibility to ensure continued U.S. prominence in nuclear medicine diagnostics, therapy and research.

Most of the infrastructure required to handle, process and ship radionuclides as well as dispose of radioactive waste exists at the Savannah River Site in Aiken, SC. Consequently, additional capital investment to enable radionuclide production and distribution from the APT facility would be limited to approximately $100 million.

Curiously, ensured production of medical isotopes is viewed differently in the U.S. than the military approach to tritium production. The U.S. Department of Energy's (DOE's) production level for tritium is established by the military and is based on 100% backup capacity, accounting for tritium decay and the possible loss of production capacity resulting from accidents, sabotage, etc. This well-established military philosophy is designed to ensure that the U.S. can meet threats to its security without the limitation of inadequate weapons.

On the other hand, the DOE, which initially supplied most of the country's medical nuclides, has (following congressional directives) relinquished that role to industry. DOE now supplies only 5% of the U.S.'s medical nuclide needs. DOE-supplied nuclides are limited to the very-high-cost, low-research-demand nuclides that are too costly for industry to produce. As a result, medical nuclide production is economically driven by the industry's view of the market.

The November workshop endorsed the perception that the medical nuclide market needs greater supply reliability. Reliance on a small number of suppliers and concerns about aging equipment and labor unrest illustrate the precarious nature of current supplies. For example, the present reactor facilities for medical nuclides are aging. When the APT accelerator comes on-line in 2005, many of these existing facilities may be too costly to keep operating. The NRU reactor in Chalk River, Ontario, Canada; the Annular Core Research Reactor at Sandia National Laboratory in Albuquerque, NM; the University of Missouri Research Reactor in Columbia, MO; and the overseas reactors are old and may become uncertain sources for neutron-produced

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radionuclides. The Maple 1 and 2 reactors in Canada to replace the NRU reactor are now under construction and may be the only new sources of reactor-produced nuclides. The situation is the same with regard to accelerators. The Brookhaven LINAC Isotope Producer (Brookhaven National Laboratory, Brookhaven, NY), the Los Alamos Neutron Science Center (Los Alamos National Laboratory, Los Alamos, NM) and the various overseas accelerators are aging and cannot be counted on for endless supplies of radioisotopes.

It was the consensus of the conference that the U.S.'s current needs for radioisotopes are being met, but there are major concerns about the stability and reliability of future supplies for medical diagnosis, therapy and research. It was felt by many that the APT has the potential to provide nuclides that could fulfill these needs.

—Kenneth M. Spicer, MD, PhD
—Seymour Baron, PhD
—G. Donald Frey, PhD
Department of Radiology and Office of Special Programs, Medical University of South Carolina, Charleston, SC

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provided, and (b) that indicated medical and technical supervision is continual[1] (repeated regularly throughout the entire patient encounter), as needed, and that (c) the Components are documented in the record. Practices that routinely employ electronic means to provide all Components should conduct regular, scheduled, and documented on-site supervision, at least every three months, to assure the quality of imaging procedures.

[1]"Continual": "repeated regularly and frequently"; *American Heritage Dictionary.*

—Wendy J.M. Smith, MPH, is the SNM director of health care policy.

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H. William Strauss, MD
President, Society of Nuclear Medicine