Technologies We Can't Afford To Ignore

by Marjorie Mazel Hecht

Nuclear medicine, the use of radioactive isotopes in diagnosing and treating disease, has a proven track record of saving lives, and saving money, by providing faster and better diagnostic results and cancer treatment with almost no unpleasant or dangerous side-effects. But although many nuclear medicine techniques were pioneered in the United States, today this country lags behind in research, development, training, and treatment.

In Europe, where nuclear medicine is overtaking standard chemotherapy treatment for certain types of cancer, a patient is more likely to find the most advanced treatment, using radioisotopes.

Every aspect of nuclear medicine is underfunded and underdeveloped here. Most striking is the fact that the United States must import over 90% of the medical radioisotopes used. When you consider that 20 million diagnostic and treatment procedures are performed annually here with radioisotopes, this level of "outsourcing" is staggering.

Eighty percent of the medical radioisotopes used in the United States come from Canada, with the rest coming from Europe and Russia. When Canada's Chalk River reactor, which is dedicated to isotope production, was shut down for a safety upgrade in November, it meant that patients in Canada and elsewhere would have to go without their needed tests and treatment for several weeks. The situation was so dire, that the Canadian Parliament met in an unprecedented special session to mandate the reopening of the reactor and the postponement of the upgrade. The Parliament judged, correctly, that the immediate risk to human lives was far greater than the hypothetical risk for which the reactor was being upgraded. On Dec. 16, the 50-year-old Chalk River reactor, which supplies half of the world's radioisotopes, went back on line.

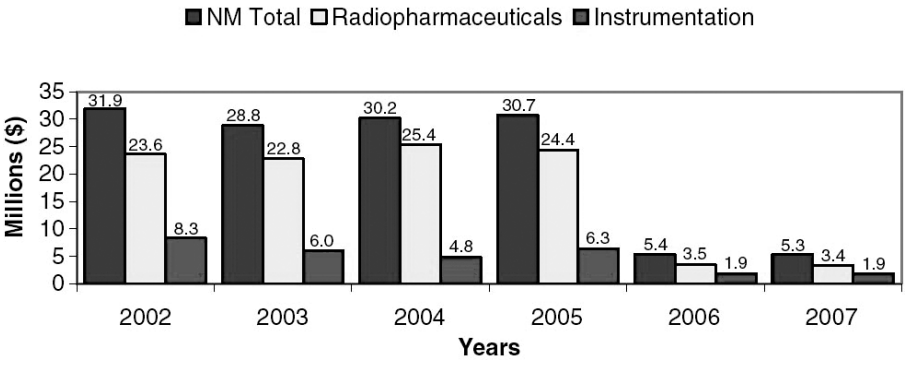
The Chalk River event points up the frustrating situation of nuclear medicine in the United States. Both the Congress and the Executive for years have ignored the many government reports advising more Federal funding for nuclear medicine research and facilities for isotope production. Perhaps as the generation of Baby Boomers ages, and suffers from the diseases of aging, their desire for advanced medical treatment will overrule their knee-jerk opposition to anything nuclear,

and these programs will get the support they need.

Academy of Sciences: More Funding Needed

The most recent of a series of scientific reviews of the nuclear medicine situation is a National Academy of Sciences (NAS) report "Advancing Nuclear Medicine Through Innovation," issued in September 2007.[1] This report comprehensively describes the promise of nuclear medicine and concludes: "In spite of these exciting possibilities, deteriorating infrastructure and loss of federal research support are jeopardizing the advancement of nuclear medicine. It is critical to revitalize the field to realize its potential."

Funding for Nuclear Medicine Research (2002-07)



Source: National Academy of Sciences, "Advancing Nuclear Medicine Through Innovation."

Declining funds, dramatically visible in this graphic, translates into declining research progress.

But although the NAS report accurately characterizes the present dismal state of U.S. infrastructure in nuclear medicine, its recommendations for isotope production are far too modest. It recommends merely that "a dedicated accelerator and an upgrade to a nuclear reactor should be considered."

The glaring omission in the NAS review is that it never mentions the Fast Flux Test Reactor (FFTF) at Hanford, Washington. This 400-megawatt sodium-cooled fast reactor was designed to test fusion and fission materials, and to produce isotopes. Yet, for no good reason, and despite a lack of domestic facilities to produce large amounts of medical isotopes, the Department of Energy (DOE) decided to shut it down in 1993, and deactivate it in 2001. In 2005, the DOE made a decision to disable the reactor, just months before the same Department announced its new Global Nuclear Energy Partnership (GNEP) program, which calls for a sodium-cooled fast reactor facility.

Fortunately, the FFTF could be reactivated, faster and at a lower expense than building a new facility. According to Dennis Spurgeon, DOE Assistant Secretary for Nuclear Energy, the FFTF "continues to be a potential option" for the GNEP program (see interview with Spurgeon in *EIR,* Nov. 23, 2007). Restarting the FFTF to produce isotopes would be a step toward meeting the current demand domestically, but an even greater capability is needed.

One of the U.S. suppliers of radioisotopes is the Advanced Test Reactor (ATR) at the Idaho National Laboratory. This is the largest research reactor in the United States, but it was not designed to produce isotopes with short half-lives. As the NAS report notes, there is a plan to upgrade it next year.

Other sources are the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory; the Brookhaven Linac Isotope Producer (BLIP), at Brookhaven National Laboratory; and the Isotope Production Facility, at Los Alamos Nuclear Science Center (LANSCE), at Los Alamos National Laboratory. All of these machines date back to the 1960s and 1970s, and were designed primarily for physics and materials science. According to the NAS report, they cannot "meet the demands of the research community for regular and continuous availability of these radionuclides," and they are limited by "age-related degradation of the facilities and extended shutdowns for facility maintenance."

There are a few research reactors at universities, which have helped in the supply of medical isotopes for research, most prominently the Missouri University Research Reactor (MURR). But many university research reactors have been shut down since the anti-nuclear decade of the 1970s, and those remaining have a limited capability for isotope production.

Without an increase in the domestic supply of radioisotopes, the United States will continue to be dependent on other countries and the vagaries of transporting short-lived isotopes over long distances.

Other Resources Lacking

The deterioration in the field of nuclear medicine is not limited to domestic production of isotopes. The nation also lacks the reservoir of students in the necessary fields and the infrastructure to ensure that there will be trained personnel in the future. The report states: "[T]here has been a substantial loss of support for the physical sciences and engineering basic to nuclear medicine. There is now no specific programmatic long-term commitment by any federal agency for maintaining high-technology infrastructure (e.g., accelerators, research reactors) or centers for instrumentation

1. Committee on State of the Science of Nuclear Medicine, National Research Council, "Advancing Nuclear Medicine Through Innovation" (Washington, D.C.: National Academy Press, September 2007).

and chemistry research and training, which are at the heart of nuclear medicine research and development."

The NAS report spells out how the isotope program is "not now meeting the needs of the research community." Public Law 101-101, the report says, "requires full-cost recovery for DOE-supplied isotopes, whether for clinical use or research [and] [t]he lack of new commercially available radiotracers over the past decade may be due in part to this legislation." In addition, the report notes, the lack of appropriate guidelines of the U.S. Food and Drug Administration for manufacturing radiopharmaceuticals hinders the development and use of new radionuclides.

The NAS report describes the research areas in need of upgrading, stressing the obvious: that there must be long-term financial commitments in order to reap the assured benefits. The report states: "There is an urgent need for the further development of highly specific technology and of targeted radiopharmaceuticals for disease diagnosis and treatment. Improvements in detector technology, image reconstruction algorithms, and advanced data processing techniques, as well as development of lower cost radionuclide production technologies (e.g., a versatile, compact, short-lived radionuclide production source), are among the research areas that should be explored for effective translation into the clinic. Such technology development frequently needs long incubation periods and cannot be carried out in standard 3- to 5-year funding cycles."

In summary, the NAS report aptly states, "We have arrived at a crossroads in nuclear medicine." The question now is whether the nuclear medicine program will take the high road to expansion, or whether it will continue to devolve, costing America both lives and money.

What Are Radioisotopes?

Radioisotopes or radionuclides are artificially produced, unstable atoms of a chemical element, which have a different number of neutrons in the nucleus, but the same number of protons and the same chemical properties. Many live for only minutes. Their existence is measured in "half-lives," how long it takes for half of the isotope to disappear.

To produce radioisotopes, a stable isotope is bombarded with fast neutrons that are produced in a nuclear reactor or a particle accelerator. The stable isotope is transmuted into an unstable isotope of the same element.

Smaller proton linear accelerators (linacs), which can be located near a medical facility are also under development, such as that of the Advanced Medical Isotope Corporation in Washington State. The fusion program of the University of Wisconsin at Madison is investigating a new method of producing isotopes in a small fusion reactor. A 1-watt fusion source has already demonstrated that it could provide very short-lived radioisotope doses for use with a PET (positron emission tomography) scanner.

From the time of the Manhattan Project, scientists had realized that nuclear fission would provide an unlimited amount of "tracer and therapeutic radioisotopes."[1] The first major use of a radioisotope was iodine-131, for diagnosis and treatment of thyroid disease. It was found that the thyroid specifically absorbs iodine.

Now, five decades later, isotope technology has developed to a high degree, defining which unique properties of radioisotopes are best at particular tasks. There are now about 200 radioisotopes in use.

Diagnostics and Treatment

Radioisotopes which emit gamma rays are used today in medical diagnostics, to provide information about how certain organs—the thyroid, bones, heart, liver, and so on—are functioning, without surgery. Radioisotopes can also be used to image the progress of certain treatments, such as shrinking tumors. The radiation does not stay in the body, and there are no side-effects.

The most frequently used radioisotope in medicine today is technetium-99m, which has a half-life of six hours. It is supplied to hospitals in a lead container of its more stable precursor, molybdenum-99, which has a half-life of 66 hours and decays to technetium-99m. The hospital extracts the technetium-99m as needed, and the container is replaced as needed.

Radioisotopes are also used in disease treatment, especially cancer, where gamma-emitting isotopes are attached to some kind of carrier, such as a monoclonal antibody, which targets particular cancer cells. The carrier delivers the radioisotope to the cancer site, where the gamma rays destroy the cancerous cells, with minimal damage to surrounding tissue.

As noted in the accompanying article, research is ongoing into the use of radioisotopes in treating AIDS and other diseases.—*Marjorie Mazel Hecht*

1. See "Availability of Radioactive Isotopes: Announcement from Headquarters, Manahattan Project, Washington, D.C." *Science,* June 14, 1946, Vol. 103, No. 2685.