1985 Nobel Peace Prize

Weapons-grade Uranium and Radiopharmaceutical Production

An IPPNW Fact Sheet

The bulk of the radioisotopes used in diagnostic medical procedures are currently derived from highly enriched uranium (HEU), which is also used to fuel plutonium and tritium production for nuclear weapons and for propulsion reactors in nuclear submarines and other naval vessels. Hans Blix, the Chair of the Weapons of Mass Destruction Commission, Mohamed ElBaradei, the Director General of the International Atomic Energy Agency (IAEA), and others have urged the phasing out of HEU from civil commerce and research facilities. They rightly reason that the use of HEU in the production of radioisotopes needlessly heightens the risk of theft of weapons-grade nuclear fuel and its diversion into the much-feared "terrorist bomb."

Four major producers of medical isotopes provide more than 95% of the global supply: MDS Nordion (Canada), TycoHealthcare/Mallinckrodt (The Netherlands), Institut National des Radioéléments (Belgium), and NECSA/NTP (South Africa). Their most important product is technetium-99 (Tc-99m), which is used in 25 million medical imaging procedures annually, constituting at least 80% of medical isotope usage worldwide. Tc-99m is the favored isotope tracer in bone scans, thyroid scans, and, increasingly, in cardiac function assessments. Tc-99m has a 6-hour half-life, so most nuclear medicine departments purchase its precursor, molybdenum, from which they then generate Tc-99m, ensuring a steady and reliable supply.

All four big producers use neutron bombardment of HEU targets in their production reactors to generate Mo-99. This process only consumes up to three percent of the available U-235 (about 10 g), so the "used" target is still bomb-grade material. As about 85kg HEU is used for these targets each year globally and the targets are not recycled, large amounts of weapons-usable material—enough for many Hiroshima-size bombs—are now stockpiled in multiple, relatively poorly secured, commercial locations.

Converting to LEU

Low-enriched uranium (LEU), containing less than 20 per cent U-235, is perfectly suitable for Mo-99/Tc-99m production and cannot be diverted to weapons use. Technical experts have reached consensus that conversion from HEU to LEU fuels and targets is possible in most instances; no future needs for HEU have been identified; and current conversion programs have been quite successful. The cost to consumers in most applications would be in the order of a one to two per cent increase. Moreover, adequate security is often far more expensive than decommissioning or converting reactors to use LEU. Yet despite the fact that there is no technical impediment to conversion from HEU to LEU target processing, none of the big players are currently using LEU. Producers in the Netherlands and South Africa say they plan to convert from HEU to LEU, but with no firm commitments or timeframes. Meanwhile the largest supplier—MD-Nordion in Canada(with approx. 60% of global market)—remains committed to HEU indefinitely.

HEU: A thumbnail sketch

Nuclear weapons are fuelled either by the fission of highly enriched uranium or by the isotope plutonium-239, which is a byproduct of the enrichment process. Natural uranium contains less than one percent U-235, the only natural isotope fissionable by neutron bombardment. Enriching uranium to at least 20% U-235 through a complicated process of isotope separation results in HEU: what the IAEA considers a "direct use" material. HEU of at least 90% U-235—weapons-grade fissile material—is required for a nuclear bomb. Without enrichment of uranium or reprocessing of spent reactor fuel to extract plutonium, there is no nuclear explosive threat. Modern thermonuclear weapons generally contain both plutonium and HEU.

The NRU Reactor at Chalk River, Canada, where MDS Nordion irradiates HEU targets to produce medical isotopes. Source: Nuclear Threat Initiative (nti.org/db/heu/civilian.html)

The truth is they are unwilling to spend the money to convert to LEU, and have lobbied aggressively against regulations that would compel them to do so.

An easy path to a terrorist bomb?

A simple nuclear weapon in the kiloton range—likely to be delivered by ship or van or assembled on site—is well within the capabilities of technically unsophisticated states, subnational groups, and international terrorist organizations such as al Qaida. The IAEA defines a "significant quantity" of fissile material as the amount required to make a first-generation Nagasaki-type implosion bomb: 8 kg for plutonium or 25 kg of U-235 contained in HEU. Modern nuclear weapons may require as little as 1 to 3 kg of plutonium or 5 to 10 kg of HEU.

HEU may be the preferred nuclear weapon material for terrorists for other reasons as well. Uranium metal can be handled relatively safely by hand and the low radiation it emits is easily hidden by even modest shielding, making smuggling extremely difficult to detect. Sixty kilograms of weapons-grade HEU could easily fit into a five-liter container.

In 2002, the US National Research Council warned that the inavailability of HEU was the "primary impediment" to the development of a terrorist bomb, and there is abundant evidence that terrorist groups have been trying aggressively to obtain nuclear materials.

A medical campaign against HEU

The health sector is a significant end user in HEU commerce. Nuclear medicine departments that purchase HEU-derived radiopharmaceuticals, and the clinicians they serve, are subject to the big suppliers' stranglehold on the supply market and thus inadvertently enable and contribute to the persistence of this vulnerable nuclear proliferation pathway. Medical needs do not require further production of either HEU or LEU. Currently, 85 kg of HEU is used annually to provide 95% of global usage of Mo-99. At this level, blending down just 10 tons of HEU to LEU would create a stockpile that could support global medical reactor-based isotope needs for more than a century.

In September 2006, **International Physicians for the Prevention of Nuclear War (IPPNW)** resolved to advocate a shift from HEU to LEU for medical isotope production. In 2008, at its Delhi Congress, IPPNW formally incorporated this objective into the **International Campaign to Abolish Nuclear Weapons (ICAN)**. Health professionals can help reduce the risk of nuclear weapons proliferation, especially by non-state terrorists, through the elimination of medical HEU commerce, by:

- ❍ urging national medical and nuclear medicine associations and other professional organizations to advocate the elimination of HEU fuel and targets from the supply chain for medical isotopes;
- ❍ promoting a code of conduct against the production, trade, and use of civilian HEU;
- ❍ optimizing use of appropriate non-ionizing radiation imaging technologies, for example MRI or ultrasound;
- ❍ optimizing use of appropriate non-reactor based ionizing radiation imaging technologies, for example PET scanning;
- ❍ promoting research and development of non-reactor generation of isotopes currently sourced from reactors, in particular Mo-99.

Nuclear reactors, including research reactors and those used to produce medical isotopes, pose proliferation, terrorism, and accident risks, and produce long-lived radioactive waste. It should cause health care professionals some disquiet that their care of patients currently, even if inadvertently, increases the risk of spread and use of the world's worst weapons of terror. Abolishing the nuclear weapons threat requires the outlawing and dismantling of nuclear weapons, but also depends on eliminating access to fissile material.

Fortunately, there are no technical obstacles to converting to low enriched uranium sources for these radiopharmaceuticals. Health care professionals are thus strategically positioned to hasten the phase-out of medical commerce in HEU, and should take concerted action to minimize the significant but avoidable contribution that their clinical practice inadvertently makes to nuclear proliferation dangers.

Additional Reading

Bill Williams and Tilman Ruff. Getting nuclear-bomb fuel out of radiopharmaceuticals. *The Lancet* 2008;371:795-7.

Laura H. Kahn and Frank von Hippel. Feasibility of eliminating the use of highly enriched uranium in the production of medical radioisotopes. *Science and Global Security* 2006;14:151-62 and "How the radiologic and medical communities can improve nuclear security. Journal of the American College of Radiology 2007;4:248-51.

Ira Helfand, Lachlan Forrow, and Jaya Tiwari. Nuclear terrorism. *BMJ* 2002;324:356-9.

Medical Association for Prevention of War. A new clear direction: securing nuclear medicine for the next generation. August 2004. Available at: www.mapw.org.au.

National Academy of Sciences. Medical isotope production without highly enriched uranium. Available at: www8.nationalacademies.org/cp/projectview.aspx?key=48752.

Papers from the Oslo symposium on the minimization of highly enriched uranium in the civilian nuclear sector. Available at: www.nrpa.no/symposium/papers/htm.

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For more information about IPPNW's campaign to get HEU out of radiopharmaceutical production, please visit ***www.ippnw.org****, or* ***www.icanw.org****, or contact Tilman Ruff (tar@unimelb.edu.au).*