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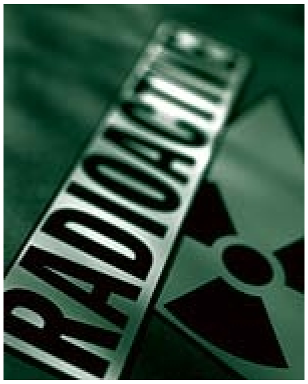
REPORT

Potassium Iodide

Protecting Yourself In a Nuclear Emergency

By Jon VanZile



It is our collective nightmare as a nation, a threat that could cause wholesale disruptions and produce mass casualties: a nuclear emergency within US borders.

This scenario is a very real and very dangerous possibility. For example, terrorists could use a so-called "dirty bomb" to render uninhabitable an area of several blocks. These devices consist of a conventional explosive rigged to spew radioactive material that is readily available from sources such as universities and hospitals. Terrorists could attack one of America's more than 100 nuclear power plants. Just imagine if the September 11 attackers had chosen to fly their hijacked jets into three or four nuclear power plants instead of buildings that stood as symbols of national political and economic might. Perhaps worst of all, a terrorist group, perhaps aided by a hostile state, could get its hands on an actual nuclear weapon.

Each of these scenarios presents a different health challenge, but each is gravely serious and potentially lethal on a large scale. A rapid response would be required from our public health infrastructure—a response that might be beyond our reach.

"There need to be plans in place," says Dana Best, MD, MPH, an attending physician at Children's National Medical Center in Washington, DC. "We need to beef up our public health infrastructure so it can do its job, which is to protect us from tornadoes, hurricanes, and nuclear weapons."

During a nuclear emergency, mass evacuations would be necessary—most likely in congested, urban areas where they could easily lead to chaos. As a second option, sheltering would be necessary to protect people from radiation exposure. This, too, would require mobilization on a massive, untested scale.

Since September 11, 2001, the federal government has struggled to update its emergency plans. Agencies such as the Department of Homeland Security, in conjunction with the Federal Emergency Management Agency and the Nuclear Regulatory Commission (NRC), have studied the issue and made recommendations to keep people safe. Fortunately, one of these recommendations is simple, effective, and widely available to anyone interested, not just government workers or people living in the shadow of a nuclear reactor.

The protection is a simple pill of potassium iodide, which contains the same form of iodine used in table salt. It has been shown in multiple studies—and in real-life experience—to safely protect people, especially children, against one dangerous side effect of radiation exposure: the development of thyroid cancer.[1,2] Because of this powerful protective effect, the Department of Homeland Security, the FDA, the NRC, the American Academy of Pediatrics, and the World Health Organization have all endorsed the distribution and use of potassium iodide.

A 2003 policy statement issued by the American Academy of Pediatrics, coauthored by Dr. Best, was very clear on the matter: "Potassium iodide is of proven value for thyroid protection but must be given before, or soon after, exposure to radioiodines, requiring its placement in homes, schools, and childcare centers."[1]

The Biology of Radiation

In the simplest terms, radiation is energy given off in waves or small particles of matter from unstable atoms. Even at low doses, radiation can penetrate the body and cause cellular damage that results in cancer many years later. At higher doses, radiation can cause severe hematopoietic syndrome, attacking the body's red and white blood cells. This syndrome can cause death in 8 to 50 days.[1]

The severity of radiation sickness directly correlates to the degree and length of exposure, and the kind of radiation involved. (For a more detailed description of radioactive substances and how radioactivity is measured, see the sidebar entitled "Understanding Radioactivity.") Radiation also affects cells in different ways, depending on their rate of division and level of specialization. The most sensitive cells are lymphoid, while the least sensitive are bone marrow and nervous system cells.[1]

One form of radiation, known as radioiodine, is particularly dangerous to the thyroid gland. Radioiodine is a common byproduct of nuclear power generation. When inhaled, radioiodine is rapidly absorbed by the thyroid gland, where it has a number of harmful effects. It may cause benign tumors, thyroid cancer, or, at high doses, hypothyroidism caused by destruction of the thyroid gland.[1,3]

Potassium iodide works by flooding the thyroid gland with easily available iodine and, if taken at the right time, preventing or completely blocking the uptake of radioactive iodine.[3]

UNDERSTANDING RADIOACTIVITY

Radiation is energy given off in the form of waves or small particles of matter. People are regularly exposed to all different kinds of radiation—from the sun, x-rays taken at the dentist's office, and innumerable other sources.

Scientists distinguish between "radiation" as energy and "radioactivity," which is a characteristic of a substance that gives off radiation. They also distinguish between "electromagnetic radiation," which has no mass and includes sunlight and x-rays, and "particle radiation," which is emitted as unstable atoms release tiny particles. All radioactive metals emit particles as they try to decay to a more stable form.

Uranium, for instance, emits particle radiation as it tries to decay to a more stable form. It takes uranium 238, one common form of natural uranium, about 4.5 billion years to decay into thorium, another radioactive metal that itself decays in 14 billion years into radium, which decays in about 1,600 years into lead. The time it takes for a radioactive element to decay into its next form is called its "half life."

Radioactivity is measured by how many "disintegration events" take place per second. In the metric system, one becquerel is one decay per second. Alternatively, the radiation emission of a radionucleotide is also measured in curries. One currie is equivalent to 37 billion disintegrations per second.

The most dangerous form of radiation energy is known as "ionizing radiation," which has enough energy to break chemical bonds in living organisms. At high enough levels, this energy can create spontaneous DNA mutations, increased production of free radicals, or disruption of basic cell structure. The five forms of ionizing radiation are alpha particles, beta particles, neutrons, gamma rays, and x-rays.

- **Alpha particles** are extremely heavy molecules consisting of two protons and two neutrons. They have a limited ability to penetrate skin or clothing, but can be ingested. Radon emits alpha particles.
- **Beta particles** are subatomic particles ejected from the nucleus of some radioactive atoms. They are equivalent to electrons. They can be inhaled or can penetrate the skin more easily than alpha particles. Beta particles come from radionuclides used in medicine (such as xenon) or are created as byproducts of nuclear reactors. Radioiodine is a beta particle.
- **Neutrons** are powerful but rare particles that are emitted only after a nuclear detonation. They are highly destructive to living tissue.
- **Gamma rays** are electromagnetic rays that are emitted from radioactive materials such as cesium or cobalt, or after a nuclear detonation. They are easily able to penetrate tissue and cells.
- **X-rays** are also part of the electromagnetic spectrum. They are unlikely to be encountered during a nuclear emergency.

There are two systems for measuring radiation dosage. The older system uses rads (radiation absorbed dose). One rad is produced when one gram of material absorbs an erg of energy (an erg is a very small unit of energy). In the metric system, rads are replaced by grays, with one gray being equal to 100 rads. The rad or gray is the amount of energy absorbed by a tissue or substance.

To calculate the biological effect of radiation, or the dose equivalent, scientists multiply the amount of energy absorbed in rads or grays by a variable called the quality factor, or QF. The QF takes into account the different degrees of biological damage produced by equal amounts of different types of radiation. For x-rays, gamma rays, and most beta particles, the QF equals one. Alpha radiation has a QF of 20, while the QF for neutrons ranges from 2 to 11.

The rem (roentgen equivalent in man) is the product of the amount of energy absorbed (in rads or grays) times the efficiency of radiation in producing biological damage (the QF). The metric system uses units called sieverts, with one sievert equal to 100 rems.

Doses above 100 rems, or one sievert, have been shown to damage red and white blood cells, causing the hematopoietic effect. Dosages above 1,000 rems cause cells lining the digestive tract to die and bacteria to invade the bloodstream, a condition known as the gastrointestinal effect. A dose of several thousand rems can lead to brain injury and death within hours.

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Chernobyl: Lessons Learned

Fortunately, scientists have not had much opportunity to study the effects of a nuclear emergency on human beings. Nuclear weapons have been used only twice against people, in Hiroshima and Nagasaki, Japan, near the end of the World War II. There have been only a handful of nuclear reactor meltdowns, and only one that released deadly levels of radioactive energy. It occurred in April 1986, at a nuclear reactor in Chernobyl, Ukraine.

Chernobyl was the first nuclear emergency large enough to threaten the health and well-being of millions of people. During that catastrophe, one of the main reactors of the power plant melted down, releasing an estimated 120 million curies of radioactive material. The surrounding land was heavily contaminated with plutonium and cesium, as well as with dangerous levels of radioactive iodine. Ultimately, more than 21,000 square kilometers of land were contaminated, and about 135,000 people were permanently evacuated. Experts later estimated that 17 million people were exposed to excess radiation,[4] including 2.3 million children living in eastern Russia, southern Belarus, and northern Ukraine.[5]

At first, scientists did not appreciate the threat posed by high levels of radioiodine released during the meltdown. It did not take long, however, to start seeing the effects. Within four years, there was a sharp spike in the incidence of thyroid cancer.[1] This increase occurred in children who had received less than 30 rems of radioiodine to the thyroid.[6] Within 15 years, more than 1,000 cases of thyroid cancer had been reported in the affected areas, a 30- to 60-fold increase.[6] All of the cases, according to the World Health Organization, were “most probably solely attributable to this single release of radioactivity to the environment.”[5] Significantly, none of these areas made potassium iodide widely available.

Following the Chernobyl meltdown, Poland immediately distributed 17 million doses of potassium iodide, including 10 million to children. This was the first time scientists had an opportunity to study the side effects of potassium iodide in a large population. The news was encouraging: side effects were clinically insignificant.[6]

Awful as it was, the Chernobyl experience confirmed a valuable lesson: children are by far the most vulnerable to radiation exposure, even in relatively small doses.[7] Children exposed to radiation suffer from higher rates of certain childhood cancers, especially leukemia and thyroid cancer, and have a greater likelihood of developing breast cancer as adults.[7]

Children’s greater vulnerability to radiation exposure is attributable to several factors, according to the American Academy of Pediatrics. First, children have higher minute ventilation, or a higher concentration of tiny capillaries in the lungs. This leads to greater radioactivity exposure from the same amount of radioactive material. Second, children are extra sensitive to the DNA-damaging effects of radioactive energy. Finally, children are more likely than adults to suffer from long-term psychological injury due to a radiation disaster.[1]

Guidelines for Protection

Fortunately, adults and children who are given potassium iodide may be completely protected from radioiodine. According to the Federal Register, “potassium iodide should be stockpiled and distributed to emergency workers and institutionalized persons for radiological emergencies at a nuclear power plant and its use should be considered for the general public within the 10-mile emergency planning zone of a nuclear power plant.”[8]

Significantly, however, this is only a recommendation. The final decision to stockpile potassium iodide has been left to state and local governments. Although the NRC has made free doses available to

TABLE 1: Potassium Iodide Dosage Guidelines

Patient age	Exposure in grays*	Potassium iodide dosage
Over 40 years	Less than 5	130 mg
18 - 40 years	Less than .1	130 mg
12 - 18 years	Less than .05	65 mg
3 - 12 years	Less than .05	65 mg
1 month - 3 years	Less than .05	32 mg
Birth - 1 month	Less than .05	16 mg
Pregnant or lactating	Less than .05	130 mg

* A gray is the International System of Units (SI) unit of energy for the absorbed dose of radiation. One gray is the absorption of one joule of radiation energy by one kilogram of matter.

local governments, a significant number of cities and states have chosen not to participate in the program. As a result, you cannot be sure whether your local government has adequate supplies of potassium iodide. Fortunately, potassium iodide pills are available over the counter.

One gray equals 100 rad, an older unit.

While the government recommends stockpiling within a 10-mile radius of a nuclear reactor, there is good reason to believe that people within a larger area should take precautions. The distribution of radioiodine is affected by wind patterns. In Chernobyl, the areas of greatest contamination were the 20-mile zone around the reactor, another region 120 miles north-northeast of the reactor, and yet another area 300 miles northeast of the reactor.[1]

In heavily congested areas—like southeastern New York state, which is close to five nuclear reactors—the American Academy of Pediatrics recommends stockpiling potassium iodide within a 50-mile radius. Other proposals have suggested a 200-mile radius.[1]

FDA-approved potassium iodide is available in 130-mg and 65-mg pills. The government has issued dosage guidelines for home use of potassium iodide, as shown in Table 1 above.

Potassium iodide can be dissolved in any liquid. Because it tastes salty, the FDA recommends dissolving it in pleasant-tasting solutions when administering it to children. Fruit beverages, including orange juice and raspberry drink, seem to hide the flavor. Chocolate milk and flat cola also can help mask the taste. Water and low-fat milk do not disguise the unpleasant taste. Each dose of potassium iodide lasts for 24 hours.

WEIGHING IN ON POTASSIUM IODIDE

The use of potassium iodide to protect people from radiation exposure is supported by a wide array of governmental and medical organizations, including:

• **American Academy of Pediatrics:**
“All children at risk should receive potassium iodide before exposure, if possible, or immediately afterward. This will require that potassium iodide be available in homes located within 10 miles of a nuclear power plant. Childcare facilities within 10 miles of a nuclear power plant should plan to stockpile the agent. It may be prudent to consider stockpiling potassium iodide within a larger radius because of more distant windborne fallout.”[1]

• **US Food and Drug Administration:**
“The effectiveness of potassium iodide as a specific blocker of thyroid radioiodine uptake is well established, as are the doses necessary for blocking uptake. As such, it is reasonable to conclude that potassium iodide will likewise be effective in reducing the risk of thyroid cancer in individuals or populations at risk for inhalation or ingestion of radioiodines.”[6]

• **World Health Organization:**
“The selective and rapid concentration and storage of radioactive iodine in the thyroid gland results in internal radiation exposure of the thyroid, which may lead to an increased risk of thyroid cancer and benign nodules and, at high doses, hypothyroidism. These risks can be reduced or even prevented by proper implementation of stable [potassium] iodine prophylaxis.”[5]

• **US Nuclear Regulatory Commission:**
“Potassium iodide, if taken within the appropriate time and at the appropriate dosage, blocks the thyroid gland’s uptake of radioactive iodine and thus reduces the risk of thyroid cancers and other diseases that might otherwise be caused by thyroid uptake of radioactive iodine that could be dispersed in a severe reactor accident.”[9]

Limitations of Potassium Iodide

Although potassium iodide has shown powerful benefits in protecting people, and especially children, against a nuclear emergency, health officials stress that it is not a perfect solution. According to the NRC, the first line of defense during a nuclear emergency is evacuation. If evacuation is impossible, sheltering is the next best solution. Ideally, people should seek shelter in concrete buildings, even skyscrapers. If exposure does occur, any contaminated clothes should be removed and discarded as soon as possible.

Potassium iodide is not entirely without side effects. In newborns, potassium iodide has been shown to decrease the blood level of thyroxine and increase the level of thyroid stimulating hormone.[1] In pregnant women, potassium iodide has been shown to cause neonatal hypothyroidism. In both cases, potassium iodide should be administered only as a last resort. People with iodine allergies should avoid potassium iodide.

Potassium iodide's effectiveness also depends on the nature of the radioactive exposure. The drug is specifically geared to thyroid protection by blocking the uptake of radioiodine, a common beta particle produced during certain nuclear reactions. However, potassium iodide offers no protective benefits against other forms of radiation, including the extremely dangerous neutrons that are released during a nuclear explosion. It is also ineffective against so-called "dirty bombs," which are constructed from radioactive material that does not contain radioiodine.

Finally, among older people and those in iodine-deficient areas, potassium iodide use has been associated with iodine-induced thyrotoxicosis. At chronic high doses, it has been shown to cause goiter or hypothyroidism. Because of this, people with multinodular goiter, Graves' disease, and autoimmune thyroiditis should be use caution and consult a physician before using potassium iodide.[6]

Despite these limitations, potassium iodide, if used quickly and correctly, is the only pharmacological approach that has ever shown specific protective effects during a nuclear emergency.[1]

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