ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

NEGATIVE EFFECTS OF URANIUM RADIATION ON THE ORGANS OF THE MOUTH

Umarova Odinakhon Numanovna

Andijan State Medical Institute, Uzbekistan

Annotation: Uranium, including depleted uranium (OU), as a rule, poses the greatest danger to human health if it enters the body by ingestion, inhalation or through cracks in the skin (prolonged contact can also lead to a large dose of external radiation). Uranium poses a threat in the body, being both a toxic heavy metal and a radioactive substance. In addition, there are a number of signs that indicate a possible synergy of these two types of effects on the body. Current U.S. federal regulations on the safety of drinking water limit the uranium content in it to 30 micrograms per liter (mcg/l), mainly based on its chemical toxicity. For natural uranium, this norm is 20 picocuries of uranium radioactivity per liter of water (pKi/l). As for depleted uranium, its concentration in drinking water cannot exceed about 12 pKi/l of uranium activity. Inhalation of uranium is limited by federal regulations mainly due to the risk of cancer, and drinking water consumption is limited mainly due to renal toxicity.

Key words: Uranium, chemical toxicity, blood.

The content of uranium in water is regulated due to its chemical toxicity - uranium is a known nephrotoxic substance, that is, toxic to the kidneys. The kidneys control the blood composition in the body and purify it of unnecessary substances. Serious doubts remain about determining the level of sensitivity of human kidneys to depleted uranium. Animal studies have shown that there are toxic thresholds that differ by more than an order of magnitude in more sensitive rabbits and less sensitive rats.

Science studying the effects of uranium on the human body is developing rapidly, largely due to health problems caused by the 1991 Gulf War, as well as the NATO bombing of the former Yugoslavia in 1999, and their gradual recognition, which became known as the Gulf War syndrome. Next, we will consider the emerging picture of the facts of this study.

Risks associated with ionizing radiation

Ionizing radiation is a known carcinogen. Its exposure increases the risk of various types of cancers. To date, the optimal awareness of the effects of low doses of radiation, which has formed the basis of regulatory activities in the United States and Europe, boils down to the fact that any increase in radiation exposure contributes to an increased risk of cancer. This is called a linear threshold-free conception2.

In general, the calculated risk per unit of exposure has increased over time, as new information about the interaction of radiation and living tissue is emerging. As a result, the maximum allowable doses were reduced. For example, in 1954, the Atomic Energy Commission set the radiation dose limit at 15 rem per year3. This was a serious decrease compared to the norm of 0.1 X-rays per day adopted in 1942 during the Manhattan Project. In 1959, the permissible dose for humans was reduced to 0.5 rem per year, and then in 1990 it was reduced again to 0.1 rem per year4.

The non-cancerous effects described below (with the exception of renal toxicity) have been demonstrated using laboratory tests, which are often carried out at elevated radiation levels. For humans, these levels have not been definitively quantified in terms of risk factors. In addition, some of the experiments described here were carried out using uranium when it was directly injected into the body of animals or with depleted uranium, which was injected in metallic form under the skin, which is completely different from the possible environmental effects resulting from the disposal of depleted uranium oxide. In addition, it has not yet been established whether there are thresholds for some non-cancerous exposures, in contrast to the generally accepted threshold-free concept of cancer risk from ionizing radiation.

An additional element of radiological protection that has emerged over time is the awareness of the relative risks for women and men. Today, the overall risk of developing fatal cancers in women when exposed to low doses of radiation and low LPE (linear energy transfer) is almost 50% higher than in men. Almost 45% of the additional risk in women per unit of exposure is due to the special sensitivity of the female breast to irradiation5. If we consider the percentage of cancers, then, regardless of the death rate, this comparison becomes slightly higher. It turns out that for women, the risk of getting any form of cancer from radiation exposure is more than 58% higher than for men.

The latest depleted uranium study

In recent years, there has been a strong increase in awareness of the risks of cancer resulting from depleted uranium radiation exposure and damage to the kidneys due to the inherent properties of heavy metals. In addition, many new facts are emerging that raise serious concerns about the consequences of constant exposure to op-amp for other body functions. Animal and human studies have shown that uranium can be contained in variable amounts in the skeleton, liver, kidneys, blood vessels and brain. In addition, experiments on rats implanted with OU tablets showed the content of uranium in the heart, lung tissue, ovaries and lymph nodes, along with other tissues.

As mentioned above, some studies have also revealed signs of a possible synergistic effect of uranium, manifested in its properties of a heavy metal and a radioactive component. A study of the risks of exposure to the heavy metal cadmium has shown a potential synergistic effect when combining effects with gamma radiation. Work with these types of combined effects revealed that direct DNA damage from radiation exposure most likely caused inhibition of the DNA repair process as a result of the presence of heavy metals. A double sword of Damocles, so to speak.

Scientific work conducted at the United States Armed Forces Radiobiology Research Institute (AFRRI), located in Besezda, Maryland, has revealed that depleted uranium can cause oxidative damage to DNA. This indicates the first signs that radiological and chemical effects of uranium have the potential not only to initiate a tumor, but also to promote its development. Next, we will discuss some of these potential health effects of depleted uranium that have been identified in many studies.

Mutagenic and carcinogenic effects

Since the late 1990s, as a result of in vitro and in vivo studies, new facts have been emerging that indicate that depleted uranium can be genotoxic, mutagenic and carcinogenic. To date, much of this research is being conducted at AFRRI under the supervision of Dr. Alexandra Miller.

For the first time, Dr. Miller and her colleagues demonstrated that digested depleted uranium can lead to a "serious increase in urinary mutagenicity" - this can be considered a common biomarker of exposure to a genotoxic substance.6 They also showed for the first time that OU irradiation is able to transform living cells into cells that can generate cancerous tumors in mice with suppressed immune systems. They found that irradiation with the same chemical doses of uranium with different isotopic structures caused "an increase in cases of neoplastic transformation depending on the specific type of activity," which further meant "that radiation can play a role in biological effects caused by OP in laboratory conditions."

Other experiments conducted by Dr. Miller and a group of scientists have also shown that OU is able to stimulate "oxidative DNA damage in the absence of serious radioactive decay." In light of another experiment by this group of researchers, which indicates the radiological potential of OU, contributing to the occurrence of genotoxic effects in vitro, the scientists noted that "so it is tempting to assume that OU is able to secrete a tumor component, both "initiating" and "developing"." This possible dual role may arise, for example, as a result of alpha particle radiation, first causing a cancerous mutation (tumor initiation), then accumulation of oxidative damage due to the properties of heavy metals and/or radioactive radiation of uranium, which contribute to the spread of cancer (tumor development) or vice versa.

What is the real role of radiological and chemical substances in genetic damage caused by depleted uranium is a serious question. Especially considering that currently the content of OH in drinking water is regulated due to its chemical hazard, which is considered as a primary problem. At the same time, it is implied that its radiation hazard is a secondary problem for the environment.

The final study, which was conducted on this issue at the aforementioned research institute, appeared in 2003 in a publication by Dr. Miller and a group of scientists on the potential of OU causing genomic instability in human cells. It is worth noting here that during radioactive decay, the op-amp emits alpha particles. The authors of this publication primarily note that:

"Studies using OU conducted in our laboratory have shown the occurrence of neoplastic transformation of human cells in conditions when about 14% of cells irradiated with OU underwent transformation, even though the alpha particle crossed less than 5% of them. The data obtained indicate that factors unrelated to direct or "targeted" DNA damage may be involved in the transformation. The chemical effects of OH and "non-targeted" radiation effects may also play a role in this process. "Non-targeted" effects can lead to damage to cells that are not affected by the alpha particle. The overall level of transformation observed may be the result of the presence of any or all of these factors."

In order to measure the effects of radiation and toxicity of heavy metals separately, the effects of depleted uranium were compared with the effects of nickel and gamma radiation.

ISSN: 2692-5206
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Based on the results of the experiments, Dr. Miller and a group of scientists came to the following conclusion:

"In the abstract, we presented data that show the formation of genomic instability in the offspring of human cells irradiated with OH. The data obtained indicate that OU is capable of causing delayed cell death, as well as genetic changes in the form of micronuclei. In comparison with gamma radiation or nickel, irradiation of the OP led to a greater manifestation of genomic instability. Although animal experiments need to be carried out in vivo in order to study the effect of long-term exposure to OH and genomic instability. The results obtained by our in vitro system can play a significant role in determining the risk assessment of OU exposure."

Effects on children and the embryo/intrauterine fetus

Children, as well as the embryo/fetus, are at increased risk due to the mutagenic and carcinogenic properties of uranium. The International Commission on Radiological Protection (ICRP) noted:

"Ionizing radiation is known to cause serious harm to cellular reproduction. Therefore, biological systems with a large number of multiplying cells show a rapid reaction to radiation. Throughout the entire period of fetal development, a high percentage of cellular reproduction was found. However, despite the fact that cellular reproduction is the main process of spreading radiation effects, the sensitivity of the embryo and fetus is also determined by processes such as modification and cellular movement, as well as radiation effects on these biological processes.

It turns out that tissues such as the brain, thyroid gland, bone and mammary gland are more sensitive to radiation if this radiation occurred during normal periods of active growth of the body (for example, in early childhood or puberty)7".

Recognizing these more serious radiation exposure risk factors for children, the annex to the Federal Environmental Protection Administration Report No. 13 of 2002 presented mortality and morbidity rates per becquerel of absorption, compiled for various age groups, including from 0 to 5 years. According to the three isotopes present in the OU, the risk of developing a fatal form of cancer in a child under five years of age per unit of absorption is approximately six to eight times higher than the average risk of this age group, which is currently guided by the Environmental Protection Department when determining absorption doses during meals and drinking water, respectively.

Summing up all that has been said - the increased risk per unit of absorption combined with the peculiar perception of the child's body of pollutants such as OH, and the fact that uranium is known to be able to cross the placental membrane and concentrate inside the embryo/fetus - it is possible to state with full confidence the need to introduce stricter requirements for the disposal of OH, especially if uranium is recognized as a more carcinogenic substance, which it is not considered to be today, and especially when it comes to protecting children's health.

Effects on reproductive functions

Reports on animal experiments assessing the effect of uranium irradiation on their reproductive functions were compiled back in the 1940s. However, it turned out that in the USA these first studies did not receive further methodical development by other American scientists And only many decades later followers appeared. Even today, there are serious gaps in the perception of the problems of uranium exposure to the reproductive ability of humans and animals.

During experiments in the 1940s, it was discovered that prolonged or even single feeding of rats with uranium could adversely affect the reproductive abilities of animals. Its effect during prolonged feeding was significantly higher than with one-time consumption of uranium. The authors noted an unexpected continuation of this effect on the reproductive cycle of rats even nine months after a single uranium irradiation.

The reason why these early investigations did not receive further or wider coverage remains unclear. However, a recent study on uranium has developed these early discoveries, and as a result of the work done, two independent areas of study of the potential effects of uranium on reproductive function have emerged. The first area relates to the risks associated with exposure to men, and the second concerns exposure to women.

Increased uranium content was found in the analyses and semen of participants in the Persian Gulf War. Although epidemiological data have not yet shown the relationship between radiation exposure and reproductive functions of war veterans, the Royal Scientific Society of Great Britain noted that the concentration of OH in analyses is a potential problem with the possible existence of synergistic effects caused by the ability of uranium to damage DNA through chemical oxidative stress and ionizing alpha radiation. In addition, the World Health Organization (WHO) noted the observation of "unidentified degenerative changes in the analyses" of rats after prolonged intake of soluble uranium compounds.

Although a very limited number, a little more research has been conducted on the effects of uranium irradiation on women's reproductive functions. They showed that uranium crosses the border of the placenta and concentrates in fetal tissue. Animal experiments have revealed that uranium irradiation - both ingestion and injection - can lead to "reduced fertility, embryo/fetus toxicity, including teratogenicity, as well as reduced offspring growth." These data were obtained in experiments on rats and mice and serve as evidence that, at least at the studied doses of uranium absorption, uranium irradiation can adversely affect the reproductive abilities of females. The only depleted uranium experiment described in the report found no statistically significant effects on "the weight gain of the expectant mother, the consumption of water or food, the period of pregnancy or the number of full-term fetuses." However, it was found that a higher number of implanted tablets with OU leads to an increase in the uranium content in the placenta and in the entire fetus of rodents.

As for the effects of uranium on reproduction, there are still many unknown factors, and a number of potential radiological and non-radiological processes have been proposed that will help explain the effects in question. These processes include hormonal or enzyme breakdown, as well as behavioral changes. In addition, we have already mentioned the conclusions of the ICRP regarding the increased overall sensitivity to radiation of the developing embryo/fetus, as well as young children, which can also potentially play a role in the effects of OU on reproduction.

ISSN: 2692-5206
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Neurotoxic effects

Limited evidence of the relationship between uranium and neurological damage dates back at least to the mid-1980s. Despite a number of problems that prevented these first studies from forming firm conclusions about the neurological risks of depleted uranium, they nevertheless served as an incentive for further work. Research that began in the 1990s has identified a number of new problems related to the potential toxic effects of OU on brain activity. One of the most serious concerns related to the latest research work is that the original chemical form of uranium in the body, the heavy toxic metal uranyl cation (UO22+), is a chemical analog of the lead cation (Pb2+). A lot is known about it, including the tragic history of neurotoxins, and it poses a separate problem for children's health.

In 1999, Dr. Pellmar and a group of scientists from AFRRI demonstrated that depleted uranium implanted in mice was concentrated in various areas of the brain, with its higher content observed at higher radiation doses. Based on these results, they concluded that uranium "accumulation in the brain, lymph nodes and testicles indicates the possible occurrence of unforeseen physiological consequences of exposure to uranium in this way.

In an additional study, Pellmar and a group of scientists went further and were able to show that "irradiation with fragments of OU led to neurophysiological changes in the seahorse." The seahorse was chosen for study due to the brain area associated with memory and learning. Based on the reviews of these AFRRI experiments, it was concluded that their results are a serious confirmation of the possible neurotoxic effects of depleted uranium.

Other researchers have proven that after ingestion, uranium concentrates in the brains of mice and rats. Some experiments on mice have shown effects on the brain with potential neurotoxicological effects at such doses of uranium irradiation, after which no visible kidney damage was detected. The latest study found noticeable behavioral changes in rats after two weeks of exposure to OU through drinking water.

A specialized computer analysis developed to assess the "efficiency factor" was used to detect potential neurological effects in participants in the Persian Gulf War who were exposed to radiation through depleted uranium ammunition. These tests were performed at the Baltimore Medical Center of the Office of Veterans Affairs of the Army (Baltimore VA Medical Center). They showed a statistically significant relationship between the uranium content in their urine and lower scores in computer neurocognitive tests. However, when using traditional neurocognitive tests, no measurable effects were found in the same group. In this case, it is important to note that the soldiers were exposed to radiation in adulthood and that these analyses do not provide information about the effects on the more sensitive stages of early childhood, when rapid brain growth and development occurs or when the blood-brain barrier has not yet been fully formed.

In addition to the potential for uranium to have a chemically neurotoxic effect similar to lead, it is also known that radiation adversely affects the nervous system of the embryo/fetus. From a review of data on Japanese survivors of the atomic bombing, the ICRP in the above-mentioned publication concluded:

"There is a whole bunch of consequences of intrauterine radiation on the development of the central nervous system - these are oligophrenia, decreased mental abilities and academic performance at school, as well as various seizures."

Later, the ICRP specified why the intrauterine period causes a special danger in radiation damage to the nervous system and why it is so important to take this into account when assessing risks:

"The development of the central nervous system begins in the first weeks of embryonic growth and continues throughout the early postpartum period. Thus, the development of the central nervous system occurs over a long period of time when it is particularly vulnerable. It has been found that the development of this system is often disrupted by ionizing radiation, so special importance should be given to these biological processes."

The effects of lead and mercury on intrauterine development also indicated a sign that these substances are capable of causing neurological damage during this period of rapid growth. However, the early years of childhood are generally considered the most critical period for exposure to heavy metals, given the higher likelihood of infants being exposed to environmental influences. As for a number of other emerging risk factors mentioned above, a synergy of chemical and radiation effects of uranium on the nervous system is also possible here.

It should be noted that even relatively small changes in the average IQ, which are common in many children, will lead "to a significant increase in the percentage of children with intelligence below any set IQ level, for example 80, as well as a decrease in the percentage of "gifted" children with intelligence above any high level, for example 120." Thus, the effects of neurotoxic substances, even in very small doses, on the population can ultimately be extremely serious, even if it does not seem so to the "average" or "ordinary" representative of the exposed population.

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