Медико-биологические проблемы жизнедеятельности

№ 1(5) 2011 г.

Научно-практический рецензируемый журнал

Учредитель
Государственное учреждение «Республиканский научно-практический центр радиационной медицины и экологии человека»

Журнал включен в Перечень научных изданий Республики Беларусь для опубликования диссертационных исследований по медицинской и биологической отраслям науки (31.12.2009, протокол 25/1)

Журнал зарегистрирован
Министерством информации Республики Беларусь,
Свид. № 762 от 6.11.2009

Подписано в печать 11.04.11.
Формат 60×90/8. Бумага офсетная.
Гарнитура «Times New Roman».
Печать цифровая. Доп тираж 46 экз.
Усл. печ. л. 22,3. Уч.-изд. л. 20,1.
Зак. 861.

Издатель ГУ «Республиканский научно-практический центр радиационной медицины и экологии человека»
ЛИ № 0230/0131895 от 3.01.2007 г.

Отпечатано в Филиале БОРБИЦ РНИУП «Институт радиологии».
220112, г. Минск,
ул. Шпилевского, 59, помещение 7Н

ISSN 2074-2088

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http://www.rcrm.by
e-mail: mbp@rcrm.by

№ 1(5)

2011

Medical and Biological Problems of Life Activity

Scientific and Practical Journal

Founder
Republican Research Centre
for Radiation Medicine
and Human Ecology

Journal registration
by the Ministry of information
of Republic of Belarus
Certificate № 762 of 6.11.2009

ISSN 2074-2088

Обзоры и проблемные статьи / Reviews and problem articles

Медико-биологические проблемы / Medical-biological problems

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Материалы Международной научно-практической конференции «25 ЛЕТ ПОСЛЕ ЧЕРНОБЫЛЬСКОЙ КАТАСТРОФЫ. Преодоление ее последствий в рамках Союзного государства» (г. Гомель, 12-13 апреля 2011 г.)

25 лет после Чернобыльской катастрофы / *25 years after Chernobyl accident*

УДК 616-056.7(437.1):614.876

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THE CZECH REPUBLIC AND THE CHERNOBYL ACCIDENT – 25 YEARS LATER

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Territory of the Czech Republic was contaminated as the result of breakdown in Chernobyl nuclear power plant in 1986. Czech population received low doses of ionizing radiation which could not cause deterministic impact. However, those low doses could have a stochastic effects expressed in years following the accident. Twenty years after accident is time long enough to assess its stochastic effects, primarily tumors and genetic impairment. Moderate amount of radioactive fallout received by Czech population in 1986 increased thyroid cancer in following years, on the other hand no obvious genetic impact was found.

Key words: *low level dose, ionizing radiation, cancer, genetic*

Introduction

On April 26, 1986, a hard technology breakdown happened in nuclear power plant in Chernobyl. It is estimated that at least 5% [1] of inventory radioactive material were released during the accident and caused contamination of a very wide area. Most contaminated territory was placed in former Soviet republics - Belarus, Ukraine and Russia [2]. In contrast to that, the Czech Republic (CR) territory, located more than 1000 kilometers away, was among the countries faced a moderate contamination by radioactive fallout [3, 4]. Reactor explosion caused radionuclides release comparable with 50 atomic bombs dropped on Hiroshima [5]. This breakdown was recognized by United Nations as the biggest nuclear catastrophe in human history [6].

Radiation contamination in CR

First signals of air contamination in CR were captured at night from April 29th to 30th 1986 during routine measurements in nuclear power plants [7]. Systematic monitoring of air contamination, fallout and was used for prediction of effective dose in population, which were far below recommended values [8].

There were 27 different radionuclides identified. Among them Iodine ^{131}I, and cesium isotopes ^{137}Cs and ^{134}Cs were recognized as the most important contaminants [9, 10]. The highest air contamination was observed in April 30th 1986. From usual values about 10-6 Bq/m^3 the volume activity values increased up to tens and hundreds Bq/m^3 (observed inhomogenity in territory contamination was caused mainly by non homogeneity of precipitation). In following days, a quick decrease of volume activity was apparent and in May 10th 1986 the volume activity decreased below 1 Bq/m^3 [7].

In the first days, Iodine ^{131}I was the most important radionuclide regarding effective doses [11, 12]. Importance of Iodine quickly decreased because of its short halftime (8 days). Since July 1986 more that 90% of the dose was evoked by Cesium isotopes and mainly ^{137}Cs, with the halftime of 30 years. The time course of volume activity of ^{137}Cs in air since 1986 up today is shown on Fig. 1A. Radioactive fallout resulted in surface contamination, which was also regularly monitored [8]. Fig. 1B shows month averages of surface activity. In June 1986, a detailed mapping of surface activity in whole Czech territory was performed with average deposition of ^{137}Cs at 7,6 kBq/m^2, maximum value at 95 kBq/m^2 and minimum was only 0,2 kBq/m^2 [7].

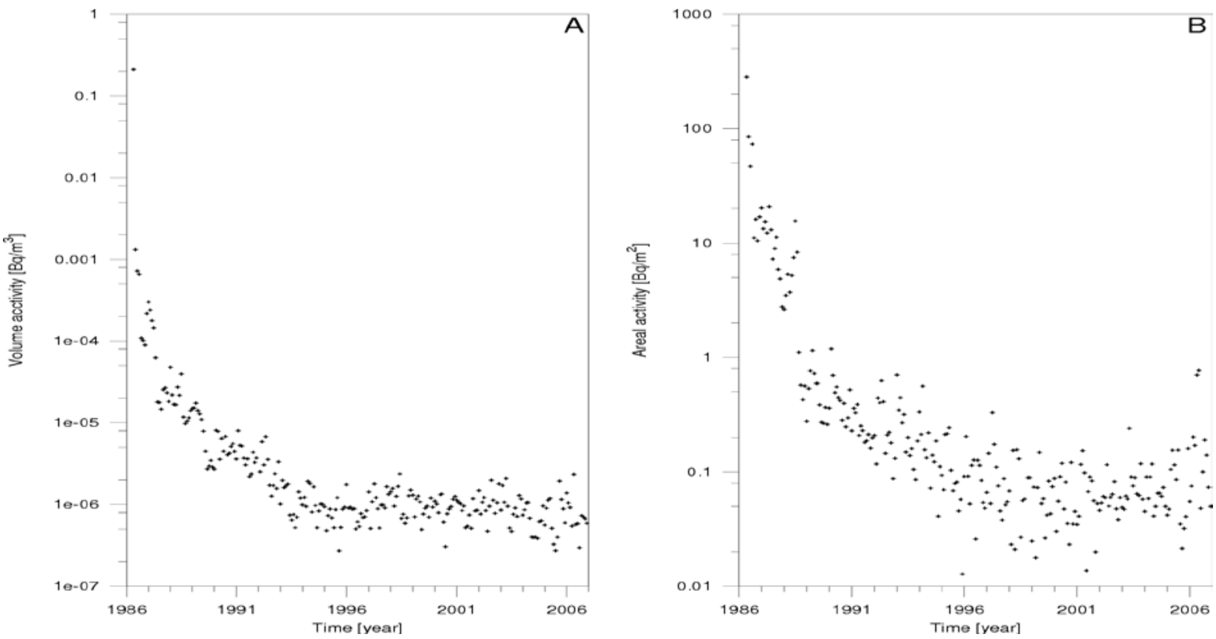

Figure 1 – Time course of volume activity (A) and surface activity (B) of ^{137}Cs in Prague (data by NRPI)

Food contamination in CR

Radioactive contamination started at the beginning of vegetation period, when the main impact on alimentary chain was represented by fresh grass, a component of cattle hay. The mass activities of important radionuclides in grass rose up to hundreds or even thousands of Bq/kg [7]. Therefore the main attention was concerned at recording radionuclides contained in milk and diary products because these were identified as the most important source of ^{131}I and Cs isotopes intake for Czech population [9].

The peak of ^{131}I activity in milk was observed in May 5th 1986 at value about 400 Bq/l. The peak of milk contamination by ^{137}Cs was found in May 10th 1986, when the values were about 50 Bq/l. Since summer 1987 it has been less that 1 Bq/l. Also some other kinds of food, particularly those most important for nutrition (meat, cereal, vegetables, fruits, mushrooms, etc.), have been recorded (shown in Fig. 2) [7].

Effective dose in CR

Radiation in environment (air, surface and alimentary chain) led to internal contamination. Fig. 3 shows retention of ^{131}I and ^{137}Cs in Czech population. Recorded activities of radionuclides in the whole body or individual organs were used for estimation of the total effective dose from Chernobyl accident, its portion related to internal and external irradiation. The time course of the effective dose among Czech population caused by Chernobyl accident with an trend assessment until 2056 is shown in Fig. 4A [9].

Health effects

Acute effect of ionizing radiation on the Czech population was not expected due to level of irradiation (0,2 mSv in 1986 attributed to Chernobyl accident [9], which was much lower than is the level for acute radiation exposure (~1000 mSv), and also no case of acute illness was reported. Due to such low level of irradiation the chronic effect of long-lasting low-level ionizing radiation [13-16] is the dominant health risk factor.

It was documented that irradiation has not only deterministic, but also stochastic effects with somatic and genetic impairment. The most serious somatic effects are solid cancers and leukemia [17, 18].

Thyroid cancer

The main source of the radiation to the thyroid caused by Chernobyl accident was ^{131}I

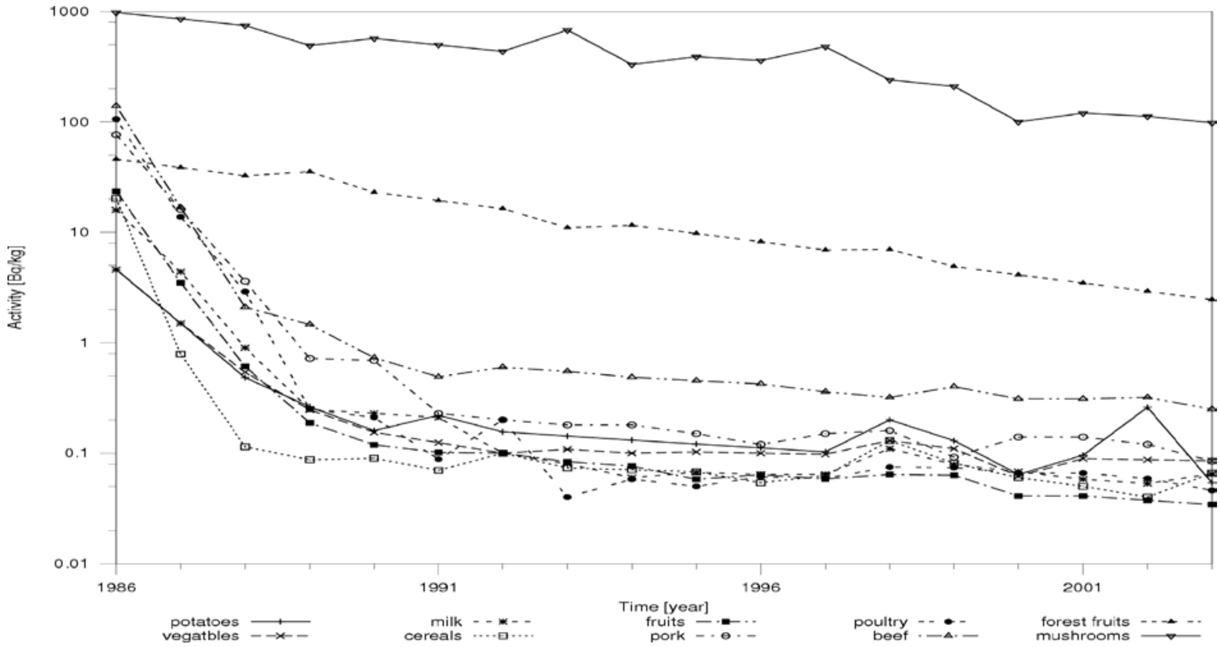

Figure 2 – Contamination by ^{137}Cs illustrated in various kinds of food (adapted from NRPI data)

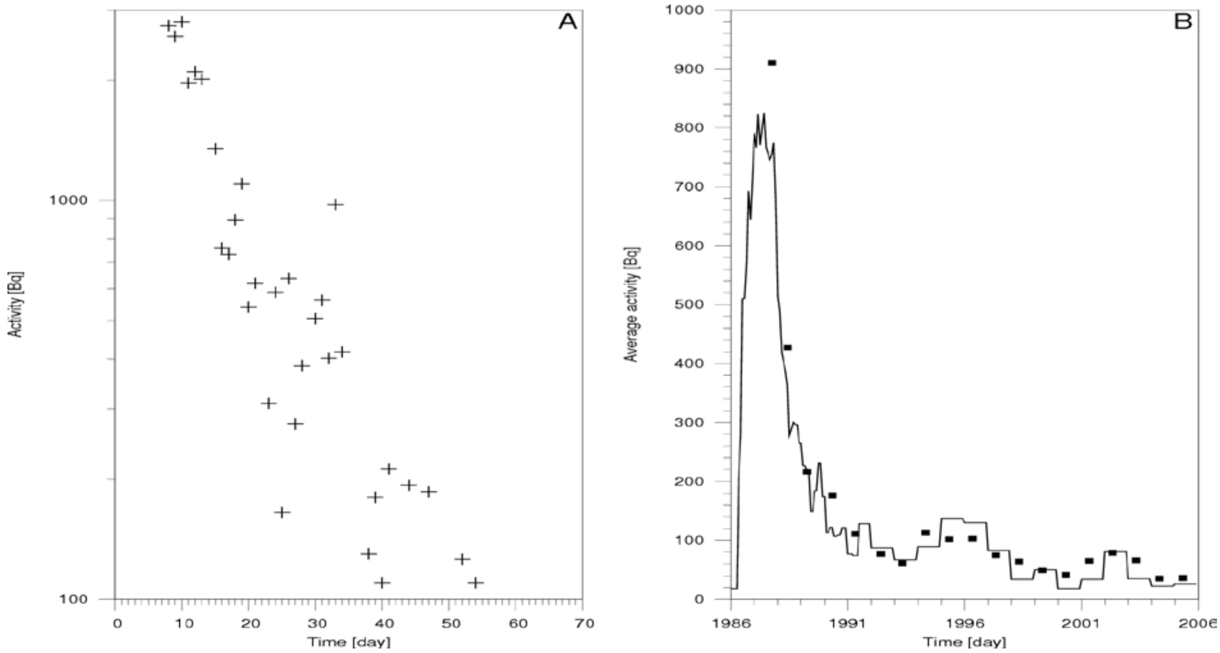

Figure 3 – Retention of ^{131}I (A) and ^{137}Cs (B) in Czech population. (adapted from NRPI data)

[19]. The first evidence of an increase in thyroid cancer incidence came in 1990, when this increase has been observed among those exposed to radioactive iodine in childhood and adolescence in the most contaminated territories of Ukraine, Belarus and Russia [20-30]. Epidemiological studies focusing on the most contaminated regions of the most affected countries have confirmed a causal relationship between the observed increased risk of thyroid cancer and exposure to radioactive iodine from the Chernobyl fallout among those who were children or adolescents when the accident happened [31-33].

In the Czech Republic, a uniform annual increase of 2,0 % per year was reported (Mürbeth et al. 2004) in the thyroid cancer incidence proportion from 1976 to 1999, it means even before the Chernobyl accident. From 1990 on, an additional significant increase in the thyroid cancer incidence of 2,6% per year was observed. The similar latency with the observations in the most contaminated territories suggests that this increase is related to the Chernobyl accident. For the territory of similar dose received by Czech population in 1986, it is estimated about 0,12 % of cases of thyroid cancer up to 2005 attributed to radiation from Chernobyl and 0,41 % up to 2065 [32]. In those who were exposed before age 15, the corresponding fraction is 1,13 % up to 2005 and 0,77 % up to 2065. Among factors suspected from increase of thyroid cancer occurrence in Poland between 1980-2000, Roszkowska and Gorynski mention also Chernobyl accident [23].

Leukemia

Except of indication of increased leukemia incidence in the extremely exposed persons (Chernobyl liquidators), no significant increased risk of malignancy, even in the regions near Chernobyl, was reported. For the territory of average whole-body dose in 1986-2005 similar to Czech population (Ireland, Poland, Hungary, Malta, Sweden, Lithuania, Italy, Norway, Slovakia, Switzerland) it is estimated about 0,06 % of cases of leukemia up to 2005 attributed to the radiation from Chernobyl and 0,03 % up to 2065 [32].

Genetics effects of low level ionizing radiation

Radiation-induced genetic mutations are stochastic events. The probability of the event depends on the dose; the degree of the damage does not [34]. The dose-dependent effect of gamma radiation on DNA damage has been described by Sudprasert [35]. Significant increases in DNA strand breaks and oxidative base damage were observed at absorbed doses of 50 and 100 mGy, respectively. Gamma radiation at 50 mGy caused chromosomal aberrations. They suggest that the genotoxic effects of gamma radiation may be due to a combination of DNA-damaging effects and reduced DNA repair capacity, and may explain the significant increase in health risk from high doses of ionizing radiation.

No article specially focused at the genetic consequences of Chernobyl accident in Czech population was found in literature. The assessment of the genetic consequences of radioactive fallout from the Chernobyl accident in the Czech Republic can be evaluated from the genetic consequences in surrounding countries facing similar radiation situation. In Poland, Cebulska-Wasilewska and Guminska (1991) examined Cracow area. They found the highest value of mutation frequency shortly after the Chernobyl accident (May 1986) [36]. In Hungary performed surveillance based on three groups of indicator conditions but the analysis did not reveal any measurable germinal mutagenic effects of the Chernobyl accident. Ehling (1987) used incidence of dominant mutations in offspring born to radiation exposed survivors of the Hiroshima and Nagasaki atomic bombings to predict the genetic damage from the fallout of the reactor accident at Chernobyl in Munich region in Germany. He expected for each 100 to 500 spontaneous dominant mutations one radiation-induced mutation in the first generation [37, 38]. Slebos tested whether ionizing radiation can cause paternal genetic mutations that are transmitted to offspring. They found out the children of Chernobyl liquidators conceived before and children conceived after their father's exposure showed no statistically significant differences in mutation frequencies. Contrary to that the results from screening of appearance of new fragments using multisite DNA [30, 39] fingerprinting [39] showed the children born to liquidator families conceived after parental exposure to low doses of radiation can induce multiple changes in human germline DNA. Melnov and Lebedeva analyzed the cytogenetic status of adolescent from the Belarus contaminated area and they found out that people living in the condition of chronic radiation influence had essentially increased general frequency of all types of chromosome aberrations and that the degree of the biological homeostasis violation is intimately connected with the level of genome destabilization [40, 41].

Discussion

Enormous amount of data have been collected during the two decades since the Chernobyl accident [42]. An important condition for a reliable evaluation of heath effect is an assessment of radiation doses received. A large number of radiation measurements conducted in the environment, foodstuffs and humans since 1986 have provided important information on this aspect. Czech Republic is among the countries whose territory was affected by moderate radioactive fallout and according to the average dose is comparable with many countries of Europe [43].

Due to distant location of CR to Chernobyl was the contamination of territory low and therefore probability of tumors or genetic consequences were also low. The absorbed doses (0,26 mSv in first year after the accident) were significantly lower then doses absorbed in medical diagnostic methods (1-3 mSv in X-ray mamography, 10 mSv in abdominal CT, 6 mSv in dynamic scintigraphy of myocardium [6, 44, 45].

For population of CR is typical Iodine deficit [46]. That is the main reason of massive intake of radioactive Iodine into thyroid gland via diary products after Chernobyl accident. Thus, in case of nuclear power plant fallout is necessary to blocade thyroid gland

The Czech population is irradiated not only due to Chernobyl accident, but also from other sources. Contribution of individual sources to the average effective dose in population during 12 month since the Chernobyl accident is shown on Fig. 4B and similar comparison of the longlife dose is shown on Fig. 4C [47].

Because of very low doses of irradiation in CR it cannot be presumed the accident impact on heredity, reproductive health and health status of children born after accident.

Psychosocial impacts of Chernobyl accident exceeded range of direct effects on health status mainly in territory close to accident. Those impacts are not correlated with real irradiation which had not necessarily needed to happen, but with subjective sense of risk. They have hundred thousands people afflicted [47]. And the consequences are noticeable many years. To psychological and social consequences (with significant impact on human lives) are attributed the insufficient awareness of radiation situation [9], emotional stress, fast relocation from contaminated territory, life quality decrease, powerlessness feeling, etc. Regarding radiation situation and socio-economical life style indicators in Czech Republic, the impacts mentioned above were not relevant.

Up today the theory of stochastic effects of low doses of radiation (situation in Czech Republic territory) is valid. Therefore we did not discussed theory of hormesis which is supported by many papers [48-58].

The accident with significant release of radionuclides can happen regardless its estimated probability is extremely low. If it will happen, then it will be solved ad hoc again. The complex functional systems of notification, warning and monitoring are the most important tools in case of radiation situation. The reactor in Chernobyl would probably have not crashed down if the operators did not trespass practically all what (for safety operating) they could, so that ionizing radiation would not thread the population of most of Europe.

Acknowledgement

The authors thank to The National Radiation Protection Institute (Jiří Hůlka) for kind data supply.

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Работа была проведена при поддержке гранта Министерства образования, молодежи и физкультуры Чешской республики (NPV II 2B08001).

Й. Росина, Я. Вранова, Е. Квашнак, Д. Шута, Т. Костргун, Л. Навратил, Й. Сабол, З. Гон, Д. Драбова

ЧЕШСКАЯ РЕСПУБЛИКА И АВАРИЯ НА ЧЕРНОБЫЛЬСКОЙ АЭС – 25 ЛЕТ СПУСТЯ

Дозы облучения населения Чешской Республики были настолько малыми, что не могли вызвать развитие детерминированных эффектов радиации, но в состоянии были индуцировать стохастические процессы. 25 лет после аварии – достаточно долгий период, чтобы определить наличие или отсутствие радиационно-индуцированных стохастических эффектов, прежде всего опухолей и генетических последствий. Проведенные нами исследования показывают, что на территории Чешской Республики после аварии на ЧАЭС наблюдалось увеличение числа первично-зарегистрированных опухолей щитовидной железы, а уровень генетических заболеваний в популяции не изменялся.

Ключевые слова: *низкая доза, ионизирующая радиация, рак, генетика*

Поступила 22.02.11