Risk Assessment of the Thyroid Cancer within the Problem of Radiation Protection for the Reactor Accidents

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INTRODUCTION

Nuclear power reactors have a large inventory of radioiodine among other radionuclides. In the event of an accident in an operating NPP involving a release of radioactivity, the iodine isotopes will be among the first fission products to be released. Radioiodine isotopes cumulate in the thyroid gland. Therefore protection of the thyroid is one of the most important issues of emergency response at the early stage of the reactor accident. Based on Chernobyl experience and latest data the protection strategy is now under reconsideration. Results of risk assessment, which were developed in Belarus, could significantly contribute to this process.

IMPACT OF THE CHERNOBYL ACCIDENT TO THE BELARUSIAN POPULATION

As a result of the Chernobyl accident about 1.3-1.8 EBq of $^{131}$I was released (1). By comparison, the Three Mile Island accident in 1979 in the US released an estimated 0.6-0.7 TBq, the Windscale accident in 1957 about 0.7 PBq, and the Hanford from 1944 to 1947 a total of 25 PBq.

The plume that escaped from the reactor moved predominantly to the northwest and northeast directions from Chernobyl NPP. As a result, the majority of Belarusian territory was contaminated with $^{131}$I (2). In five out of 6 regions of Belarus, density of contamination with $^{131}$I ranged from 0.4 to 37 MBq/sq.m. (3). The highest levels of contamination density were registered on the territories closest to the NPP (southern part of Belarus). The contamination decreased with the distance from the NPP.

Because of late warning of the population and incompleteness of measurements for thyroid protection, significant doses were formed to the thyroid glands of Belarusian people. According to recent estimation, the collective thyroid dose for all the population of Belarus is 510,000 person-Sv (4). This estimation takes into account only doses from ingestion of $^{131}$I and does not count short-lived isotopes of iodine, as well as inhalation of $^{131}$I. Children up to 6 years old who lived in the southern part of Belarus, received highest thyroid doses. Exposure from $^{131}$I caused conditions for thyroid stochastic consequences among the exposed population.

The level of the thyroid cancer incidence in Belarus before the Chernobyl accident (1971-1985) was low for children (0.04 per 10$^5$ children population annually) and relatively higher for adults (0.3-2.5 per 10$^5$ for men and 1.2-3.9 per 10$^5$ for women) (5).

After the accident, the thyroid cancer incidence started to increase and since 1990, significant increase of the incidence rate among exposed children was registered. Among children and adolescents under 18 years of age in 1986, the incidence rate of thyroid cancer was: 1.15 per 10$^5$ in 1990; 2.7 per 10$^5$ in 1991; 3.17 per 10$^5$ in 1994; 5.0 per 10$^5$ in 1995; 4.63 per 10$^5$ in 1996 (6). Similar increase in the incidence was observed among the exposed children of Ukraine and Russia (6,7,8). In 1997 and 1998 the incidence rate was similar to that in 1996. Current incidence of the thyroid cancer among exposed children and adolescents can be considered now on a plateau.

USE OF THE CHERNOBYL EXPERIENCE FOR THYROID GLAND PROTECTION

In order to arrange the efficient protection of the thyroid gland in the case of the reactor accident the main questions to be answered are: what is the efficiency of main radionuclides of iodine in the induction of thyroid cancer; when thyroid blocking should be given; at what distance the thyroid blocking should be applied; what is the dose criteria to be used? The results of investigation carried out in Belarus after the Chernobyl accident can provide answers to some of these questions, especially regarding the efficiency of internal exposure from $^{131}$I in the induction of thyroid cancer, as this radionuclide gave the main input in the formation of the thyroid dose for the Belarusian population.

The role of $^{131}$I in the induction of thyroid cancer among exposed youth was studied on the cohorts of those exposed with $^{131}$I for diagnostic purposes in USA and Sweden (9,10) and exposed population of Marshall Islands and Utah from the nuclear testing (11,12).

The results of these investigations are limited and have low statistical power. Nevertheless they showed lower efficiency of $^{131}$I in comparison with external gamma and X-ray exposure. The efficiency of $^{131}$I in the induction of radiation induced thyroid cancers was considered to be three times less than from external gamma and X-ray exposure (13). The results of investigation carried out in Belarus in 1991-1996 showed that the
NCRP model with the assumption of lower efficiency of $^{131}$I and risk coefficient of $2.5 \times 10^4$ PYGy doesn’t describe the excess incidence rate of thyroid cancers in Belarus (14,15). Using the distribution of thyroid cancer cases among persons aged 0-6 years in 1986 with the data about thyroid doses based on direct measurements (4) the estimation of risk coefficient was carried out. Risk coefficient was calculated based on the additive model using linear dose-response relationship. The calculated value of absolute risk coefficient for $^{131}$I exposure of children was $4.5 \times 10^{-4}$ PYGy (6) which can be compared with the value for external exposure.

The results of joint investigation of the excess thyroid cancer cases in three affected countries confirmed that absolute risk of radiation-induced thyroid cancer after external gamma- or X-ray exposure may be close to the absolute risk of such cancer due to internal $^{131}$I exposure after the Chernobyl accident (Table 1).

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of investigated subjects</th>
<th>Age of exposure, years</th>
<th>Average thyroid dose, Gy</th>
<th>Absolute risk per $10^4$ PYGy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-bomb survivors (16,17)</td>
<td>13,000</td>
<td>&lt; 15</td>
<td>0.23</td>
<td>2.7</td>
</tr>
<tr>
<td>Tinea capitis (18)</td>
<td>10,834</td>
<td>&lt; 15</td>
<td>0.09</td>
<td>7.6</td>
</tr>
<tr>
<td>Pooled analysis of seven studies (17)</td>
<td>120,000</td>
<td>all ages</td>
<td>0.09-12.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Exposed children of Belarus, Russia, Ukraine (7)</td>
<td>2,328,000</td>
<td>&lt; 14</td>
<td>0.05-0.92</td>
<td>2.3</td>
</tr>
<tr>
<td>Exposed children of Belarus (6)</td>
<td>500,347</td>
<td>&lt; 6</td>
<td>0.23</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The next aspect to be discussed in the frame of thyroid gland protection after the reactor accident is the distance on which the preparation for thyroid blocking should be in place. Chernobyl consequences in Belarus showed that radiation-induced thyroid cancers are registered among the population near the plant and also among people who were living at a considerable distance. Among the population exposed under age 18 years who lived in the Gomel and Brest regions within 100 km from the NPP, the average annual incidence rate of thyroid cancer during 1991-1997 was $31.0 \times 10^5$; from 100 to 200 km - 10.9; from 200 to 300 km - 13.5; from 300 to 400 km - 3.3; more than 400 km - 1.6 per $10^5$. These increased incidence rates show the necessity of thyroid protection from uptake of radioiodine at great distance from the accident. It’s clear that those who were living within 100 km from the NPP received the highest thyroid doses. But the collective dose becomes higher with the distance from the NPP. The high incidence rate among those exposed in Minsk, which is located about 300 km from the Chernobyl NPP, confirms the necessity of thyroid gland protection at such a distance. It’s important to stress that the recent IAEA generic intervention level for thyroid blocking was exceeded for the people who were living up to 400 km from the reactor.

The results of the analysis show that protection of the thyroid gland in the case of the reactor accident should be considered more carefully using the new information about efficiency of $^{131}$I in the induction of the thyroid cancers. Based on the risk analysis data from the Chernobyl accident dose criteria for thyroid gland protection may require reconsideration.

REFERENCES
2. M.G.Gernenchuk, I.I.Matveenko, O.M.Zhukova, Assessment of radiation situation on the territory of the Republic of Belarus under conditions of pollution after catastrophe on Chernobyl nuclear power plant with the use of Gis RECASS. Ottawa, 2, 1269-1280 (1994).


