Chernobyl-related Thyroid Cancer: What Evidence for Role of Short-lived Iodines?

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Over 500 cases of thyroid cancer were diagnosed in Belarus between 1986 and 1995 among persons exposed as children (under 15 years of age) to radioactive contamination from the Chernobyl nuclear accident. There is little doubt that radioactive iodine isotopes emitted during the nuclear explosion and subsequent fire were instrumental in causing malignancy in this particular organ. Comparison of the observed geographic distribution of Chernobyl-associated thyroid cancer incidence rates by districts with contamination maps of radioactive fallout shows a better fit for estimated 131I contamination than for 137Cs. Because 131I used for medical purposes had not been considered carcinogenic in humans in the past, and in view of the unusually short latency period between exposure and clinical manifestation of cancer, it is suspected that not only 131I but also energy-rich shorter-lived radioiodines may have played a role in post-Chernobyl thyroid carcinogenesis. Measurements of iodine isotopes are not available, but reconstruction of geographic distributions and estimations of radioactive fallout based on meteorological observations immediately following the accident could provide a basis for comparison with the distribution of thyroid cancer cases. In this paper, data from the Epidemiological Cancer Register for Belarus will be used to show geographic and time trends of thyroid cancer incidence rates in the period from 1986 to 1995 among persons who were exposed as children, and these will be compared with the estimated contamination by radioiodines. Tentative conclusions are drawn from the available evidence and further research requirements discussed. — Environ Health Perspect 105(Suppl 6):1483–1486 (1997)

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Introduction

First suspicions of an increased incidence of thyroid cancer in children arose in Ukraine, where three well examined cases had occurred close to Chernobyl in 1990 (1). A year later, Belarusian scientists reported an increase of cases of thyroid cancer in children as well (2). However, scientists in the West remained skeptical, and a number of possible artifacts were brought forward (3–5). These included active case finding and previous underreporting. A main argument was the unexpected geographical distribution: There were only a few cases of thyroid cancer in Mogilev Oblast, some parts of which are known for their high 137Cs radioactive contamination. This argument later lost its validity, as it appeared that contamination with radioactive iodine did not strongly parallel cesium deposition because of changes in meteorological conditions, with winds in different directions at different altitudes and continuing release of radioactivity over 10 days, which resulted in a complex dispersion pattern (6,7). However, radioactive iodine is more likely to induce thyroid cancer than cesium because the latter is much less attracted or not attracted at all to the thyroid gland.

This paper examines to what extent a relationship between radioactive exposure and thyroid cancer incidence in individuals who were children in 1986 can be studied with available epidemiologic data and draws conclusions about the direction of future research.

Materials and Methods

Basic data included all cancer cases reported to the Belarus Centre for Medical Technology (Minsk, Belarus) and transmitted until 1995 to the State Research Institute of Oncology and Medical Radiology (Lesnoy/Minsk, Belarus), where they were processed in cooperation with the Institute of Social and Preventive Medicine of the University of Bern, Bern, Switzerland. Although the geographical analysis was intended to cover only individuals under 15 years of age in 1986, the first steps in data processing also included those born from 1963 on. This large number of cases was selected to obtain a larger basis for assessing the age distribution on the one hand and reliability of testing for multiple reporting on the other. This was accomplished using a probabilistic linkage method (8) followed by manual control, and revealed 48 of 857 cases (5.6%) to be duplicates. The resulting database contained 809 cases. In 18 of the cases cancer was diagnosed before 1986 and therefore could not be related to the Chernobyl accident. Thus, the final database consisted of 791 cases of thyroid cancer diagnosed between 1 January 1986 and 31 December 1995 in individuals born in 1963 or later.

Census data of the Belarusian population of 1989 were available in DBase 3 format. They included figures for all age groups in steps of 5 years up to age 80 and older for both genders. Separate figures for urban and rural populations as well as sum values allowed quality assessment through crosschecking. There were no inconsistencies.

Time trends and age distribution were analyzed over all cases. Geographic analysis including counting of cases by district and calculation of incidence rates included only patients less than 15 years of age in 1986. The number of individuals under age 15 at the 1989 population count was taken as a midperiod estimate for 1986 to 1995 and multiplied by 10 (10 years of observation time). Because 72% of all districts had only three cases or less, age and age–sex stratification were not done; thus, the rates are crude rates.

The data were processed on an IBM-PC clone computer. Data management and programming of analysis software were done in the FoxPro program V.2.6 (Microsoft Corp.). Geographic display was done using Map Studio, a geographical information system (GIS) developed and programmed by Krivoruchko et al., GIS

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Results and Discussion

The oldest cancer patient was 32 at the time of diagnosis. Because the registered data did not reflect the month of birth, 30 June was taken as the effective date for age calculation. Figure 1 shows the age distribution over all individuals with thyroid cancer born after 1962 and diagnosed between 1986 and 1995. As the Belarus population is distributed quite equally over the five age groups up to 24 years (19–22% contribution), an age-adjusted analysis of the age distribution would reveal an almost equal pattern. The small number of cases with 1987 or later as the year of birth suggests that the thyroids of individuals not yet born at the time of the accident will not be affected by cancer related to the Chernobyl accident. In addition, the increase in cases with birth dates closer to the time of the accident suggests an increase in sensitivity of the thyroid to radiation with decreasing age. The number of cases born in 1985 and 1986 is smaller than that of those born in 1983 and 1984. Because the accident occurred at the end of April 1986, two-thirds of the children born in 1986 or one-third of those born in 1985 to 1986 were born after the accident, thus reducing the numbers exposed. If all had been exposed, this would have led to about 130 cases rather than the observed 87 cases shown in Figure 1. This estimate should be verified when data on exact dates of birth become available.

According to the age distribution, there is again an increase in cancer incidence in individuals born in 1971 or earlier. Under normal circumstances, thyroid cancer occurs more often in adults than in children. It is unclear, however, whether the increase shown in Figure 1 is attributable to this reason or if there are other reasons.

To avoid an artifact attributable to the normal incidence increases with age in adults, further analysis was restricted to individuals who were less than 15 years old in 1986. Also, the seven children born in 1987 or later were not included in the following data analysis. It is understood that 10 years after the accident, children who were older than age 4 in 1986 will not be counted if they developed a cancer in 1995, as long as the investigations remain limited to cancer in children. Therefore, analyses of a cohort of individuals who were children at the time of the accident give a more realistic picture of the situation.

The data in Table 1 may differ from the numbers of cases published earlier (9–11). In addition to the fact that many numbers are related to age at diagnosis, differences in data sources and other methodological issues may also have an impact. Table 1 reflects major efforts to eliminate overreporting. The automatic probabilistic linkage and subsequent human control determine if two similar records are both counted or considered duplicates; in doubtful cases the decision remains arbitrary. Nevertheless, the number of cases published to date is of about the same magnitude. Table 1 suggests that a steady increase in the number of new cases will occur over time; the next years will either confirm or refute this suggestion. At present, there are not enough data to extrapolate into the future and predict future trends.

In addition to the distribution of the number of childhood thyroid cancer cases over time, the spatial distribution is of major interest. The numbers of cases detected between 1986 and 1995 by districts vary considerably. Gomel, including the city of Gomel, with 95 cases, and Minsk, including the city of Minsk, with 54 cases, have the largest numbers of cases. If these numbers are related to population figures by district, the calculated incidence density in this period reaches as high as 1.72/10,000 person-years. As the age group 0 to 4 years, which has the most cases, varies only ± 10.6%, and the gender ratio (63% of females) is relatively balanced, it is acceptable to compare crude rates.

Figure 2 shows the incidence density by district. Bragin to the east of Chernobyl (1.72/10,000 person-years), followed by Narovlya (1.68/10,000 person-years), and Hoiniki (1.28/10,000 person-years) have the highest incidence density (1986–1995) for children younger than 15 years in 1986. The vicinity of these three districts to Chernobyl suggests a relation between thyroid cancer in children and the Chernobyl accident. This is supported by a comparison with published estimations of 131I contamination as of 10 May 1986 (shown in Figure 3). The similarity of the geographical distributions of 131I and of thyroid cancer incidence densities of persons exposed as children in 1986 is remarkable. In particular, besides the increase in the region of Gomel, an increase both in disease incidence and estimated contamination with 131I west of Chernobyl in an area over 300 km from the accident site is striking. The distribution of the 18 cases was excluded because they occurred before the Chernobyl accident and gave no indication of a particular precancerous pattern that could affect the interpretation of results.

Table 1. New cases of thyroid cancer in individuals who were children (<15 years of age) in 1986.

| Year    | New cases, no |
|---------|---------------|
| 1986    | 2             |
| 1987    | 5             |
| 1988    | 5             |
| 1989    | 6             |
| 1990    | 30            |
| 1991    | 66            |
| 1992    | 73            |
| 1993    | 115           |
| 1994    | 105           |
| 1995    | 121           |
| Total   | 528           |

Figure 1. Numbers of new cases of thyroid cancer by individual's date of birth; diagnosed between 1986 and 1995.
volatile contributed substantially to the radioactive material ejected during the first phase of the nuclear accident (7). In the first hours after the explosion, the wind transported the radioactive plume in a northwesterly direction (12, 13), where short-lived radioiodines may have been deposited in areas affected by rainfall. By 30 April 1986, by which time most of the short-lived radioiodines should have been dispersed, the wind changed to the southeast and the northeast, which led to contamination by the longer-lived $^{131}$I in these regions. Rather than relating disease incidence densities to only contamination data, correlations between the geographical distribution of disease frequencies and meteorological indicators for different days could therefore add some useful information about the role of short-lived radioiodines.

As far as field measurements of environmental contamination are concerned, they can be used only when obtained within the first few days after the accident because of the short half-life of radioiodines; therefore, few data from actual measurements are available for that time. As a substitute, determination of concentrations of long-lived $^{131}$I in soil specimens and other methods of dose reconstruction are being investigated (14). Because this is a very time-consuming and cost-intensive task, coverage of the whole of Belarus will not be achieved soon. We therefore propose to carefully take the incidence density of children’s thyroid cancer into consideration when deciding on locations for soil samples for reconstruction of soil contamination by short-lived radioiodines.

In all these cases, rather than using purely visual methods, comparison of geographical distributions should be done by formal statistical testing. The needed methodology is currently being developed.

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