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RADIOACTIVE IODINE AND CESIUM IN TRAVELLERS TO DIFFERENT PARTS OF EUROPE AFTER THE CHERNOBYL ACCIDENT

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Abstract

Thyroid uptake of ^{131}I was measured in 130 volunteers following the nuclear power plant accident at Chernobyl in April 1986. Ninety of these volunteers had been travelling in different parts of eastern Europe at the time of or immediately after the accident while 40 persons were permanently in Sweden. Also, 28 additional healthy volunteers, living in Sweden, were chosen for a long-term follow-up of the time-course of ^{134}Cs and ^{137}Cs whole body uptake. The highest levels of ^{131}I were found in persons having visited Poland (mean value 3.27 kBq±3.68 SD, extrapolated to April 27) while persons that had stayed in other parts of eastern or northern Europe showed significantly lower levels ($p<0.01$). The whole body burdens of cesium radionuclides were barely detectable immediately after the accident but increased gradually throughout the observed period. After five months nine farmers from a high fallout area in central Sweden had reached mean values of 4.20 kBq (±3.34 SD) of ^{134}Cs and ^{137}Cs while six non-farmers from the Stockholm area showed significantly lower levels, 0.64 kBq (±0.24 SD, $p<0.05$). The radiation doses from the observed amounts of iodine and cesium isotopes reported in this study reflect only a marginal addition to the already existing dose from the natural environmental background radiation.

Key words: Radionuclides; Chernobyl accident, radioiodine, radiocesium, in vivo measurements, travellers.

The nuclear power plant accident at Chernobyl in the Soviet Union on 26 April 1986 created an airborne spread of radioactive isotopes to neighbouring areas. Although no acute radiation symptoms occurred outside the Soviet Union, the amount of radioactive fallout has been clearly detectable thousands of kilometers from the accident site.

The purpose of the present investigation was to study the thyroid uptake of ^{131}I, which, in a situation like this, was expected to be one of the first detectable radionuclides in vivo. Due to the short half life of this isotope (8 days) its radioactivity quickly decreases. The long half lives of ^{134}Cs and ^{137}Cs, 2 and 30 years, respectively, indicate a greater risk of gradually increased accumulation in man over longer periods of time. For this reason, we initiated a long-term follow-up study of the whole body burdens of cesium radionuclides of healthy volunteers.

Material and Methods

Patients

^{131}I. A total of 130 apparently healthy volunteers were examined for ^{131}I content in the thyroid gland. Forty of these persons were permanently staying in Sweden (group 1) while 90 had been travelling in eastern Europe at the time of or during the week following the Chernobyl accident. This group was further divided into four subgroups: 24 persons had been in the Soviet Union or Finland (group 2), 30 in Poland (group 3), 26 in central eastern Europe incl. Hungary, Austria and Czechoslovakia (group 4) and 10 in the southeastern part of Europe incl. Romania, Bulgaria, Yugoslavia and Albania (group 5). All ^{131}I measurements were performed between 30 April and 23 May 1986.

^{134}Cs and ^{137}Cs. The whole body content of cesium isotopes was tested in 28 healthy volunteers. Thirteen of these were farmers from the Gävle area in eastern Sweden where the long-term radioactive fallout was found to be high: in September 1986 a ground activity of 40 to 150 kBq per m^2 as compared with <3 kBq per m^2 in the Stockholm area (1). The tests were run from 10 June to 30 November 1986.

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Table 1

Thyroid content of ^{131}J (kBq) extrapolated to 27 April 1986

	Group				
	1 Sweden (n=40)	2 Soviet Union, Finland (n=24)	3 Poland (n=30)	4 Hungary, Austria, Czechoslovakia (n=26)	5 Romania, Yugoslavia, Albania, Bulgaria (n=10)
Median	0.54	0.48	2.00	0.89	1.10
Mean	0.58	0.65	3.27	0.97	1.10
SD	0.39	0.61	3.68	0.43	0.62

Table 2

Whole body burdens of ^{134}Cs and ^{137}Cs (kBq) in Swedish farmers in Gästrikland and Uppland counties compared with non-farmers in the Stockholm area

	10 to 30 June 1986		7 to 9 October 1986
Farmers	n=13 Mean=0.37±0.12 SD Range=0.20–0.62	n<0.001	n=9 Mean=4.20±3.55 SD Range=1.58–11.14
	p=0.04		p=0.02
Non-farmers	n=7 Mean=0.25±0.12 SD Range=0.10–0.45	n<0.01	n=7 Mean=0.64±0.24 SD Range=0.35–0.97

Measurement procedure

^{131}I activity was determined as previously described (5) using a whole body counter equipped with two NaI crystal detectors, two amplifiers (Canberra 816 A), a multiplexer (ORTEC 476–4) and a multichannel analyser (Intertechnique 45). The crystals were stationary 16 cm above and below the thyroid gland during measurement. The total number of events, as well as background events, were registered during 400 s. Thick steel walls of the whole body counter reduced the background activity by a factor of 100.

Energy calibration of the multichannel analyser was made employing standards of ^{57}Co (122 keV), ^{131}I (364 keV) and ^{137}Cs (662 keV). The iodine standard was measured in a neck phantom and used to determine the calibration factor (Bq/number of counts).

^{134}Cs and ^{137}Cs. Energy calibration for the measurement of cesium radionuclides was performed using standards of ^{57}Co (122 keV), ^{134}Cs (605 keV), ^{137}Cs (662 keV) and ^{60}Co (1 173 keV and 1 322 keV). A scanning device with the two detectors 16 cm above and below the center of the subjects and with the scanning speed adjusted so as to provide constant geometric measuring efficiency as previously described (5) was used. Measurements lasted 35 min. A calibration factor (Bq/number of counts) was obtained from measurement of a body phantom containing ^{134}Cs and ^{137}Cs in the ratio 1 : 3.

Evaluations

After background subtraction, the measured count rates were converted to values for ^{131}I activity of the thyroid gland and for ^{134}Cs+^{137}Cs whole body activity, respectively, using calibration factors. These factors were calculated from the known radioactivity of the isotope standards. Mean peak counting efficiency values were: ^{131}I 9.9 cps/kBq; ^{134}Cs 2.64 cps/kBq; ^{137}Cs 1.73 cps/kBq.

The peak ^{131}I content for each person was extrapolated from the measured content assuming an exponential decrease from 27 April to the time measurement. The effective half life was assumed to be six days. The activities of ^{134}Cs and ^{137}Cs were added together and expressed as total whole body activity of cesium isotopes. In general, the activity of ^{134}Cs was approximately half of that of ^{137}Cs in the fallout over Sweden. The physical half life of ^{137}Cs is 30 years but the effective biologic half life in man is only about 70 days (3).

Iodine prophylaxis

Twelve of the 30 persons visiting Poland had received single dose iodine solution. The iodine was given on 30 April to 10 of the 12 persons but one started the prophylaxis as late as on 5 May.

Results

Within one week after the accident the main isotope detected in the volunteers was ^{131}I. The activities of ^{134}Cs

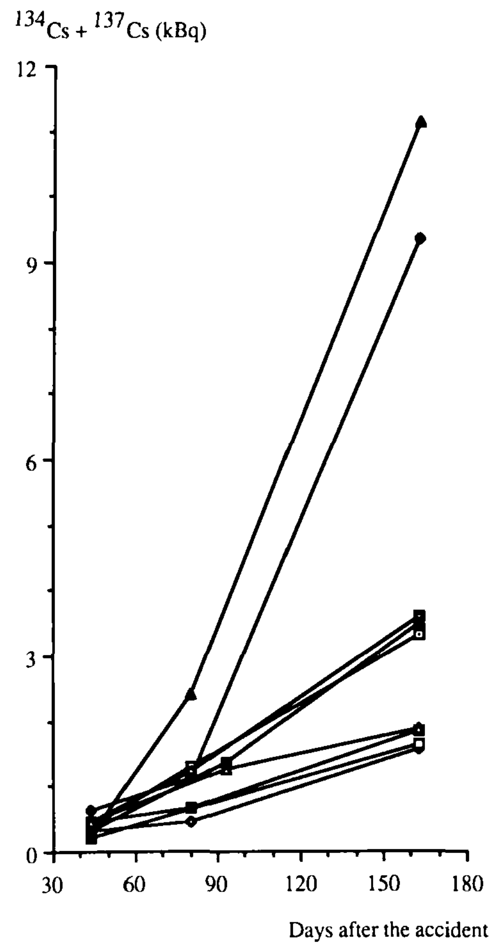

Figure. Whole body burdens of ^{134}Cs and ^{137}Cs of nine farmers in the Gävle area of central Sweden after the Chernobyl accident.

and ^{137}Cs were initially low but increased throughout the study time. Minute activities, barely distinguishable from background values, also appeared initially within the energy levels of ^{97}Zr and ^{106}Ru.

^{131}I uptake. Thyroid content of ^{131}I extrapolated to 27 April is shown in Table 1. The group of persons having visited Poland had significantly higher values than any of the other four groups ($p<0.01$, Student's t-test). The highest activity (17 kBq) was discovered in a man who had stayed in Mazurkie in north-eastern Poland between 27 and 29 April and in Warsaw between 29 and 30 April. Only 13 of the 27 persons in the Polish group showed values below 2.0 kBq. The other four groups displayed lower ^{131}I levels. The highest value outside Poland, 2.7 kBq, was detected in a woman who travelled from Kiev to Moscow by train at noon 26 April and then stayed in Moscow until 2 May. Of the remaining persons in the Soviet Union group, apart from three visitors to Jalta, nobody had been south or west of the accident site at Chernobyl after 25 April.

Iodine prophylaxis. The calculated mean content of ^{131}I for the iodine treated persons visiting Poland (n=12) was 2.0 kBq (median 2.0 kBq) compared with a mean of 4.1 kBq (median 2.0 kBq) for those who visited Poland and did not take any iodine (n=18). These values were not significantly different. However, 5 out of 18 persons in the non-prophylaxis group showed values above 4 kBq (highest value 17 kBq) compared with none of the 12 in the prophylaxis group.

^{134}Cs and ^{137}Cs uptake. Within the first weeks after the accident the whole body burdens of cesium isotopes were barely detectable, but repeated tests showed continually increasing values (Table 2). Farmers from the Gästrikland —Uppland area of relatively high fallout showed significantly higher levels than the Stockholm non-farmer controls. This was true already in June ($p=0.04$) but the difference was even more striking in October ($p=0.02$). Both groups presented significantly elevated whole body burdens of cesium isotopes in October as compared with June (farmers $p<0.001$, non-farmers $p<0.01$).

The individual values of nine farmers tested repeatedly 45 to 165 days after the accident are shown in the Figure. All nine subjects showed continually increasing activity of cesium isotopes with the highest values reaching 11.1 kBq.

Discussion

The nuclear power plant explosion at Chernobyl on 26 April 1986 resulted in a major local fallout of radioactive material. Twenty-nine persons were reported killed as a result of lethal doses of external radiation in the order of several Sv (4). The radioactive fallout in neighbouring countries has been much less dramatic. In Sweden the accident is believed to have added a mean of 0.3 mSv per person 1986 to an already existing external background effective dose equivalent of about 7 mSv, of which about 5 mSv represent pulmonary exposure to radon daughters in dwellings (1). The long-term internal radiation dose equivalent in the farmers, mainly due to cesium isotopes, is estimated to consist of about 0.3 mSv per year compared with 0.04 mSv in the non-farmer controls.

Measurements of the ground activity performed by the Swedish National Institute of Radiation Protection show that in most areas in Sweden the maximum ground activity of ^{131}I was reached on 29 April (3). Because of a windshift from southeast to northeast between 26 April and 1 May the maximum ground activity in the other parts of Eastern Europe (groups 2–4) was expected to have occurred a few days later. The ^{131}I content of the thyroid of the volunteers may thus have reached a maximum later than on 27 April. However, the peak ^{131}I content for each patient was extrapolated from the measured content assuming an exponential decrease from 27 April. In addition, some of the ^{131}I in the thyroid at the time of measurement could have been accumulated after 27 April. Thus, our peak levels may well be overestimated. Among our 130 volunteers the maximum ^{131}I activity found over the thyroid gland was 17 kBq while the majority of subjects showed values below 2 kBq. It seems highly unlikely that such an exposure could have any measurable in vivo effects. Iodine thyroid scanning tests, performed routinly in clinical practice, usually involve the administration of approximately 100 to 2000 kBq ^{131}I. An extensive study performed in 1985 of patients undergoing this type of thyroid isotope examination revealed no increased risk of developing thyroid cancer (2).

We found a numerical but not statistically significant difference in ^{131}I activity between geographically matched groups of persons with or without intake of iodine prophylaxis. This might be explained by the late start of the iodine administration. To be of any effect it needs to be initiated within hours or even minutes after exposure. None of our volunteers started earlier than four days after the accident. However, if there had been a prolonged inflow of radioactive iodine isotopes during several days after the accident a protective effect of the prophylaxis given would have been expected. The fact that the five persons with the highest ^{131}I levels all were without prophylaxis might support the suggestion of a prolonged inflow.

While the radioactive iodine quickly vanished, the cesium isotopes continued to accumulate throughout the observed period. This accumulation was particularly noticeable in farmers from the high fallout area in central Sweden. A high consumption of dairy products, meat and vegetables from this contaminated region, or possibly the inhalation of dust during farmwork, could explain the differences between these farmers and non-farmers in the Stockholm area.

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