4. The Chernobyl Fallout and the Thyroid Gland

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INTRODUCTION

One of the consequences of the Chernobyl reactor accident, on April 26th 1986, has been the release of an unprecedented amount of radioactive isotopes of iodine, mainly I-131 but also Te-132/I-132, into the environment. The total amounts of these isotopes released have been estimated to be in the order of magnitude of 10^{17} Bq.[1)] The radioactive cloud has spread in northern and western directions over a great part of Europe in the following days. Considerable deposition of fallout to distances of more than 2,000 km from Chernobyl, has been mainly dependent on the widely different patterns of rainfall in the first week after the accident.

About 10% of the estimated total absorbed dose from fallout will have been caused by exposure to radioactive isotopes in the first month. One third to one half of this early exposure can be described to I-131, mainly by ingestion and partly by inhalation.

FRAME OF REFERENCE

To understand the effects of exposure to nuclear radiation one needs a frame of reference with regard to the different types of radiation and to the estimation and comparison of risks (see Fig. 1). As far as the thyroid is concerned the risk to be discussed is the induction of thyroid cancer. In dealing with exposure one has to consider external irradiation (X-ray and gamma radiation) on the one hand and on the other internal irradiation by ingestion or inhalation. An exposure to 100 mR (approximately equivalent to one year cosmic radiation at a rate of about 10 μR/h), will result in an absorbed dose of 1 mSv. This measure will be used as a reference value throughout this article.

In dealing with effects of internal exposure to radioactive isotopes there are two specific complicating factors, which may be a source of uncertainty in the outcome of risk estimates. The first is dosimetry for internal radiation. Fur further calculations a value of 1 mSv will be used throughout this paper as the committed dose equivalent to the thyroid after the oral ingestion of 2,000 Bq of I-131 adults. This value is based on the uptake of 30–35% in a 20 g thyroid.[2)] The second complicating factor is the effect of dose rate, which may have a considerable influence on the dose response curve. This is particularly relevant in discussing the effects of different radio isotopes of iodine. Unjustly, this is often not taken into account in most risk estimates of cancer, which are based on the experience with external irradiation.

The estimates of the life time risk of fatal cancer used by ICRP are 1.25×10^{-5} per mSv for all tumours in the

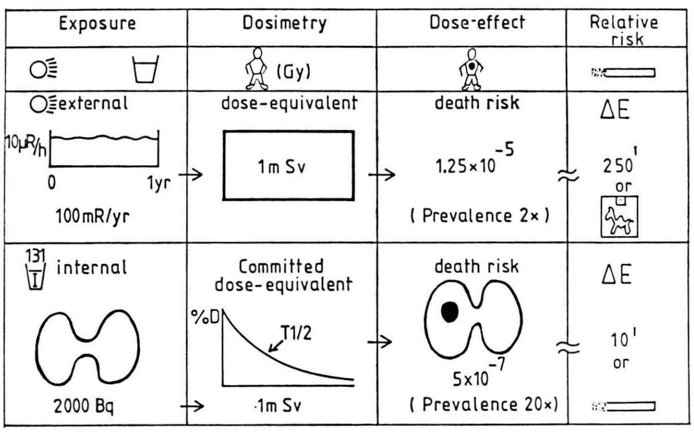

Fig. 1

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whole body and 5×10^{-7} per mSv for thyroid cancer. The incidence rates are respectively two fold and twenty fold. To compare these risks with other risks in our society one can express a risk of death in loss of life expectancy (E). This will be approximately 250 min. for the effect of one mSv on the whole body and 10 min. for this effect on the thyroid respectively, assuming a life expectancy of about 70 years. According to Cohen and Lee this is equivalent to the risk of dying from lung cancer caused by smoking a package or one cigarette respectively.[3]

EXPOSURE TO FALLOUT OF I-131

Reported gamma exposure rates, outside Russia, have reached a maximum of 400 μR/h locally in Sweden, approximately 100 μR/h in central Europe, and 20 μR/h in The Netherlands 1,800 km from Chernobyl.[4] The ambient air concentrations and the accumulated depositions of I-131 have been reconstructed with the use of two different computer models, the Mesos-model (Imperial College UK) and the GRID-model (RIVM/KNMI The Netherlands). Both models have provided data that are in reasonable agreement with each other and with reported measurements of radioactivity in several European countries. Ground deposition of I-131 in Europe ranged from less than 5 kBq to more than 200 kBq per square metre.[5]

The thyroid gland has been exposed to radiation through the consumption of milk and leafy vegetables. The reported maximum concentrations of I-131 in farm milk have been widely different in Western European countries ranging from less than one hundred to several thousands of Bq/*l*, depending to a great extent on whether or not protective measures were taken such as keeping cows indoors.[4] The highest content of I-131 in vegetables in The Netherlands has been up to 10.000 Bq/kg. As a result of protective measures the average exposure to I-131 by ingestion and inhalation in The Netherlands has been limited to 600 Bq. In other European countries particularly Poland and Austria the exposure has been 10 to 20 fold with average values locally (including the Kiev area) probably not passing 60.000 Bq.[1]

In consequence of the much shorter half-life of Te-132 and its daughter I-132 (3.5 and 2.4 hours respectively) and the delay in ingestion of contaminated food products of at least a few days, the contributions of this isotope to the exposure of the thyroid gland will have been less than 1%, at least in The Netherlands.

THE THYROID DOSE

The average absorbed dose equivalent for adults in The Netherlands has been estimated to be 0.3 mSv.[1] For other European countries average values might have been 10 to 20 fold higher, with maximum values of 30 mSv locally. For one year old children the absorbed dose will be about 5 fold higher due to a greater uptake per gram of thyroid tissue, giving an average upper value of about 150 mSv. In individual cases one might expect to find absorbed dose equivalents that are still higher. There are some published data on actual measurements of the thyroid content of I-131 and calculated absorbed doses therefrom in individual persons. Castronovo has measured I-131 uptake in travellers return-

EXPOSURE	DOSIMETRY	DOSE-EFFECT	RELATIVE RISK
≠ 131 I		†	ΔE
Hyperthyroidism 200 MBq	$\bar{x}$ 100 Sv	No exces?	none?
Holm's study* 2 MBq	$\bar{x}$ 1 Sv	No exces!	none!
Pop. individual 100.000 Bq	max 50 mSv/yr	$< 2.5 \times 10^{-5}$/yr	≪ 8 hrs
Chernobyl 600 Bq	$\bar{x}$ 0.3 mSv	$< 15 \times 10^{-8}$	≪ 3'
Neth 14×10^{6}	≈ 0.01 mSv eff.	† < 2 in 40 yrs	≪ 1 cig.

* LE Holm, G Lundell, G Walinder. J Natl Cancer Inst. 64: 1055-59 (1980).

Fig. 2

ing from Europe (including Poland and Russia) and estimated individually absorbed doses, which are in agreement with the mentioned calculated estimates.[6] Measurements from thyroid glands obtained at autopsy are available from Genova, Italy, where exposure rates were about the same as or higher than, in The Netherlands.[7] The mean value was found to be 0.21 mSv. Taking all published estimater and data together an average value of less than 0.1 to 20 mSv for the committed dose equivalent to the thyroid of adults in different countries of Europe seems a reliable basis for the calculation of the risk of thyroid cancer.[5]

THE RISK OF THYROID CANCER

Assuming that the risk estimates used by the ICRP are valid for I-131, the number of fatal thyroid cancers caused by the Chernobyl accident in the following 40 years would be two cases on a population of 14 million in The Netherlands (see Fig. 2). In other European countries the number would be proportional to that, depending on the dose estimates and the number of people involved. However, there are good reasons to Largue that this is a great overestimation of the actual risk. From several studies on the effect of diagnostic and therapeutic doses of I-131, the conclusion can be drawn that the carcinogenic potency of I-131 in men is at most 1/10 and probably only 1/100 that of external irradiation.[8] After follow-up of many thousands of patients for average periods of up to 20 years there is even no significant evidence at all that I-131 has any carcinogenic potency in man.

When the average absorbed dose in Europe is taken to be in the order of magnitude of 2 mSv the actual number of fatal thyroid cancers caused by the Chernobyl fallout will therefore probably be not more than 5 cases and certainly not more than 50 cases in the following 40 years for the whole population of Europe of about 500 million people. So all together the health risk by exposure of the thyroid to radioiodine has been far less than the risk of smoking only one cigarette.

It seems that one can not escape the conclusion that, from a point of view of public health, the effects of the Chernobyl fallout on the thyroid are much lower than often presumed. It is the personal opinion of the author that one should stop overemphasizing the preventive use of stable iodine. Instead one should give more attention to the protection from external irradiation by sheltering if needed, and to the prevention of nuclear reactor accidents.

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5. World-Wide ^{131}I Fallout in Animal Thyroids, 1954–1987

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Iodine isotopes constitute a major fraction of the biologically important volatile forms of fresh radioactive fission products which are distributed throughout the atmosphere of the earth. The thyroid gland of ruminants selectively accumulates the iodine isotopes from wide distributions during several weeks and thereby averages the biological exposure. Continuous measurement of ^{131}I in thyroids of cattle and sheep since 1954 has proven to be the most sensitive biological indicator of nuclear weapons tests and nuclear accidents. From

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