

Radiation Exposure Caused by Nuclear Power Plant Accident and Thyroid Cancer

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I. Introduction

Twenty-five years has been passed since the Chernobyl accident, and last year in 2011 in Japan, Fukushima Nuclear Power Plant Accident (NPPA) has occurred. Increased incidence of thyroid cancer following the accident in the youth (under age 18, especially in children) in Chernobyl was reported in “UNSCEAR Report in 2008”.

We have already showed the first oncology models (hypothesis) of thyroid cancer development in Hiroshima (after the A-bomb) and in Chernobyl. Then newly summarized hypothesis of thyroid cancer development in Chernobyl in children (youth) will be explained from the points of the (A) initiating factor, (B) thyroid injuries caused by I-131, (C) small cancer foci (microcancer), (D) promoting factors, and (E) characteristics of clinical cancers.

Then after showing the reports and comments related to thyroid cancer in the “UNSCEAR Report in 2008”, our comments will be added from our datas and experiences. And the possibilities if thyroid cancer in children develop or not develop in the future in Fukushima will be explained from the unfavorable faces and profitable faces compared with the results in Chernobyl. Related papers and books are listed in the References at the end of this paper.

II. New oncology model, hypothesis of thyroid cancer development in children in Chernobyl.

New oncology model is shown in Figure 1. Explanations below (from ①–③) will follow the same numbers in this Figure.

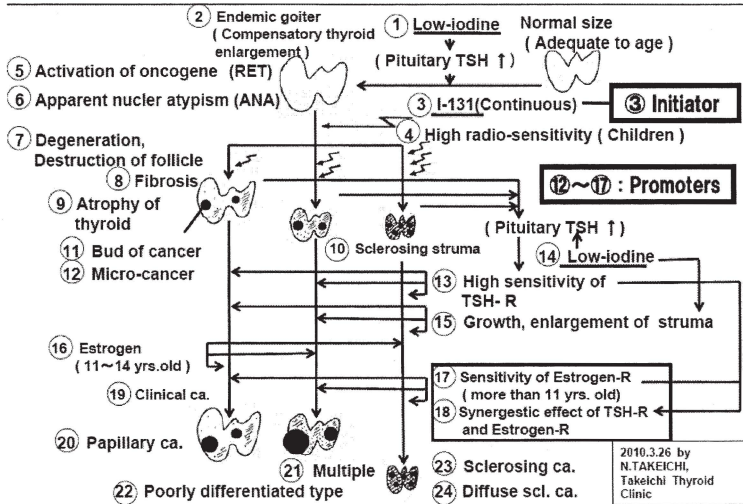
(A) Initiating factor

Conditions in the affected areas of natural iodine, struma and I-131 were as follows (①–③). ① The affected area in Chernobyl was low natural iodine region. ② Therefore the cases of compensatory thyroid enlargement (endemic goiter) were common in these affected areas. ③ Following the NPPA, a large continuous uptake of radioactive iodine (I-131) into the thyroid occurred. This I-131 is thought as a initiator of thyroid cancer after NPPA.

(B) Thyroid injuries by I-131

Following ④–⑩ were estimated as a result of thyroid injuries caused by I-131. ④ Due to the high radiosensitivity of children’s thyroid cells, ⑤ oncogene (such as RET) in the nuclei of follicular cells were activated, ⑥ and apparent nuclear atypism (ANA) revealed in these follicular cells. ⑦

Fig. 1. New Hypothesis of the Process of Thyroid Cancer Development in Radiation Exposed Children after the Chernobyl Nuclear Power Plant Accident.



Degeneration and destruction of follicle cells, subsequent variation in follicle size including follicular atrophy, lymphocytic infiltration occurred, ⑧ and fibrosis advanced. This degree of fibrosis corresponded to I-131 contamination levels. ⑨ Atrophy of thyroid (atrophic struma) revealed and advanced, ⑩ and the struma showing strong interstitial fibrosis with hard consistency was so-called sclerosing struma.

(C) Small cancer foci (microcancer)

In these degenerated, destructed, fibrotic, atrophic thyroid, small cancer foci revealed. ⑪ Bud of cancer, that is the smallest cancer lesion, appeared in these injured thyroid, ⑫ and enlarged to microcancer (usually smaller than 1.0 cm in adults, but smaller than 0.3~0.5 cm in cases of children).

(D) Promoting factors

Then why did such microcancers rapidly grew within 4~5 years after the Chernobyl accident, and became clinical cancers? The possibilities of this promoting factors, (promoters) are listed in the following ⑬~⑰. ⑬ The first possibilities is the high sensitivity of TSH-receptor of children's thyroid. ⑭ Second possible reason is that the low-iodine condition continued for a long time after the accident, and this condition stimulated normal thyroid cells to proliferate and compensate the decreased thyroid function, and also at the same time stimulated thyroid cancer cells to proliferate. ⑮ Third is the remarkable natural growth and enlargement of thyroid struma in children and the youth (under 18 yrs. old). ⑯ Fourth is estrogenic stimulus in female of 11~18 yrs. old. ⑰ Fifth is the sensitivity of

estrogen-receptor (estrogen-R) in young female. ⑱ And sixth is the synergistic effect of sensitivities of TSH-R and estrogen-R. ⑲ With the combination of these above mentioned six promoting factors, it is suspected that microcancer of children rapidly grew to clinical cancer in Chernobyl.

(E) Characteristics of clinical thyroid cancer

These clinical cancers following the Chernobyl accident had the characteristics as follows (⑳-㉔). ⑳ High frequency of papillary cancer (histo-pathologically), ㉑ multiple cancer foci in thyroid (struma), ㉒ including the high rate of poorly differentiated type (different from real poorly differentiated papillary cancer), ㉓ sclerotic thyroid cancer (sclerosing cancer) which was characterized by rich of fibrosis in cancer lesion, ㉔ and, diffuse sclerosing cancer which was a diffuse sclerosing variant of papillary cancer showing mixture of cancer tissue and remarkable fibrosis. This sclerosing cancer was a typical characteristic of thyroid cancer developed in the I-131 heavily exposed children.

III. UNSCEAR report in 2008

In the UNSCEAR (United Nations) Report in 2008, following results and comments related to thyroid cancer in Chernobyl were contained. ① Thyroid cancer cases of 6,848 were reported among those under 18 years old in 1986, between 1991 and 2005, and 5,127 cases of them were in children (0-14 yrs. old). ② The increase began to appear 5 years after the accident, and persisted up until 2005. ③ And excess increased incidence of thyroid cancer is related to the estimated individual doses due primary to the radioiodine released during the accident. ④ Substantial portion could be attributed to drinking milk in 1986 contaminated by iodine-131. ⑤ Evidence has also emerged since the UNSCEAR 2000 Report indicating that iodine deficiency might have influenced the risk of thyroid cancer resulting from exposure to the radioactive isotopes of iodine, released during the accident. ⑥ The estimation of radiation risk from these studies remain somewhat uncertain however. And may have been influenced by variations in the use of ultrasonography and mass screening after the accident. ⑦ Although thyroid cancer incidence continues to increase for this group, up to 2005 only 15 cases had proved fatal.

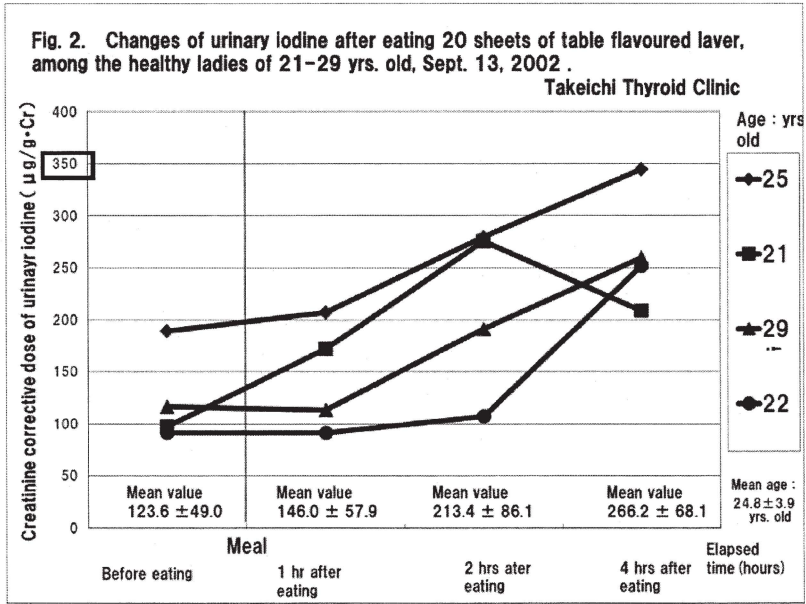
IV. Comments on the UNSCEAR Report.

I like to give some comments on the items of above-mentioned ②-⑦ from our data, and the events in Fukushima NPPA.

② The period of this UNSCEAR Report of thyroid cancer was 1991-2005, so that the data in 1986-1990 was not included. Our survey and datas in Belarus and Ukraine indicated that the increased incidence of thyroid cancer in children began to appear in 1990, 4 years after the Chernobyl accident.

③ From the UNSCEAR Report, thyroid doses of iodine-131 ranged up to several grays within a few weeks after the accident. Unfortunately in Fukushima, individual absorbed doses of I-131 in thyroid in adequate groups or adequate numbers of children were not measured.

④ In UNSCEAR Report, the contamination of fresh milk with iodine-131 and the lack of prompt countermeasures led to high thyroid doses, particularly among children in the former Soviet Union, is written. In Fukushima area it is said that I-131 contaminated cow's milk was not circulated from the early stage after the NPP accident, and the level of radiation dose of cow's milk in Japan (upper standard value,



regulated radiation dose by The Nuclear Safety Commission) was strict 100 Bq/L for children and 300 Bq/L for adult. The maximum I-131 dose measured in Fukushima (40 km from NPP) was 5,300 Bq/L, in cow's milk in March 11~April, 2011.

⑤ As shown in UNSCEAR Report, iodine deficiency might have influenced thyroid cancer caused by I-131. I-131 was easily uptaken in thyroid in the low iodine regions such as the affected areas of Chernobyl. However residents in Fukushima area commonly taking natural iodine enriched food, such as seaweeds species. We have reported the comparison of urinary iodine levels in children between Chernobyl and Hiroshima in (1993~2002). Approximate creatinine correct dose of iodine in urine ($\mu\text{g} / \text{g} \cdot \text{Cr}$) was about 50 in Chernobyl and about 300 in Hiroshima. Both cities of Hiroshima and Fukushima faces to the sea and residents were thought to eat natural iodine rich food. Here we have new data shown in Figure.2. Changes of urinary iodine after eating 20 sheets of table flavoured laver (seasoned laver) among the healthy four ladies of 21–29 years old, who were working at Takeichi Thyroid Clinic, were shown. All of other 8 ladies who showed more than $300\mu\text{g} / \text{g} \cdot \text{Cr}$ of urinary iodine before eating this flavoured laver were not included here. Average level of 266.2 after 4 hours after eating was almost 2.2 times higher than the level of 123.6. This 266.2 was almost same level (about 300) of general Japanese people. So that I-131 uptake in thyroid will be prevented by taking this 20 sheets of table flavoured laver, soon after the accident.

⑥ This explanation of UNSCEAR Report about the risk factors of radiation effect on thyroid cancer is agreeable. Small thyroid nodules are found more easily using advanced and precise ultrasonography. So that the real epidemiological results should be based on cancer size, measured by same type or same

Table 1. Estimated Conditions of Thyroid after Fukushima Daiichi Nuclear Power Plant Accident
 Unfavorable faces Profitable faces

| Unfavorable faces | Profitable faces |
|---|--|
| 1. I-131 leakage occurred. | People within 20 km zone went out in early stage after the accident. |
| 2. I-131 is easily uptaken in thyroid in low iodine regions. | Residents in Fukushima are commonly taking diet of rich iodine, such as seaweeds species, because they live seaside. |
| 3. Potassium iodine was not delivered soon after the accident. | Apparent regenerative activity is seen in thyroid follicles even in the strongly destructed thyroid in children, and this activity compensate the thyroid function. |
| 4. Thyroid of children is sensitive to I-131 effect, and is destructed easily. | But half-life of I-131 is short 8 days, and vanish in almost 3 months. |
| 5. Thyroid cancers were induced in children by I-131. | Released I-131 dose in Fukushima was estimated as one sixteenth (1/16) of that in Chernobyl (1,800,000 TBq). |
| 6. Four furnaces of NPP had accident in Fukushima, and I-131 leakage has been lasted for a long time. Estimated released dose was about 110,000 TBq. | Early detection of thyroid cancer is possible with periodical thyroid examinations. Even if thyroid cancer occurred, prognosis of this cancer is usually better compared with other cancers. |
| 7. Residents have fear for the possibilities of thyroid cancer development. | Many cases of microcancer (≦ 1.0 cm) are stable and have long prognosis throughout the life. |
| 8. Thyroid cancer is surgically operated, basically. | Enlargement of the tumor was controllable with taking continuous thyroid medicine (T4). |
| 9. Surgical operation is the final method for the large clinical thyroid cancers. | Recurrence and metastasis are well controllable with post-operative administration of thyroid medicine (T4). |
| 10. Operation scar remains in the foreneck, and children have mental burden. | With the early detection and early operation, transformation to the poor prognosis of cancer will be prevented. |
| 11. There is a possibilities of transformation from well differentiated cancer to the poorly differentiated and or anaplastic cancer of poor prognosis. | In Fukushima, it was strict 100 Bq / L for children, and 300 Bq / L for adults. I-131 contaminated milk was not circulated, from the early stage after the NPP accident. |
| 12. I-131 contaminated cow's milk was drunk in Chernobyl. And maximum approval dose in cow's milk for children was 1,000 Bq / L and 2,000 Bq / L for adults | |

through ultrasonography. And also doctor's skill and ability to find the cancer might be considered in this sense.

⑦ UNSCEAR Report says only 15 cases were fatal in 6,848 thyroid cancer, between 1991 and 2005, amongst those under age 18 years in 1986. However the age at death of those fatal cases were all less than 37 years old (until 2005). Fatal cases of thyroid cancer who died under age 37 years are very very rare (almost none) in the field of thyroid surgery. So that I think we have to be careful for the prognosis of thyroid cancer cases caused by I-131 contamination while in childhood.

V. Estimated conditions of thyroid after Fukushima Daiichi NPPA from the aspects of unfavorable faces and profitable faces.

From these conditions in Fukushima in this Table 1 and also experiences and knowledges obtained in Chernobyl, it is suspected that the incidence of thyroid cancer in children (youth) following Fukushima NPPA will not so increase as in Chernobyl. Even though, why Nation or responsible persons in Japan did not order children to escape from the 20–30km zone from NPP, and also why iodine–K (potassium) was not delivered to the residents in peripheral area of NPP (within 30km from NPP) soon after the accident. If these two were enforced, risk of thyroid cancer development in the youth, who were exposed to I-131 while they were childhood in 2011, might not increase apparently in the future in Fukushima.

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