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Thyroid Screening Survey on Children after the Fukushima Daiichi Nuclear Power Plant Accident

Yoichiro Hosokawa[1*], Masahiro Hosoda[1], Akifumi Nakata[2], Masanori Kon[3], Mayumi Urushizaka[1] and Mitsuaki A. Yoshida[2]

[1]Department of Radiological Life Sciences, Graduate School of Health Sciences, Hirosaki University. 66-1 Hon-cho, Hirosaki, Aomori 036-8564 Japan
[2]Department of Radiation Biology, Institute of Radiation Emergency Medicine, Hirosaki University. 66-1 Hon-cho, Hirosaki, Aomori 036-8564 Japan
[3]Department of Radiology, Hirosaki University Hospital 53 Hon-cho, Hirosaki, Aomori 036-8563 Japan

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Thyroid screening surveys were performed on children, ages one to fifteen, in Iwaki City, Kawamata-machi and Iitate Village from March 24 to 30 after the Fukushima Daiichi Nuclear Power Plant by The Nuclear Safety Commission of Japan. Our Hirosaki team measured radiation does in thyroids on 258 children at the Kawamata-machi Public Citizens' Hall on March 29, and on 302 children at the Iitate Village Office on March 30. The method was a simple measurement by using a scintillation survey meter made by Aloka Co. Ltd.. Background value was recorded immediately before a thyroid surveys. The neck of each participant was then decontaminated by wiping with a sterile towel, and a radiation dose was measured by attaching a probe to the thyroid. In order to get the net value of internal exposing thyroid, the value of the background was subtracted from the thyroid measurement. The total 560 cases analyzed by the Hirosaki team on March 29 and 30 are included in the 1,080 cases, done up to May 24-30, which were reported by the support Team for Residents Affected by Nuclear Incidents. The highest measured value was 0.1 μSv/h. The values less than 0.01 μSv/h accounted for 55.4%, and these equal to or less than 0.04 μSv/h for 99.0 % of the total.

Key words: thyroid screening survey, Fukushima Daiichi Nuclear Power Plant, radioactive iodine, dosimetry

1. Introduction

The Fukushima Daiichi Nuclear Power Plant Accident, after the Great East Japan Earthquake on March 11, 2011, caused a large-scale radiation disaster. The hydrogen explosion occurred in the Unit 1 Reactor building on March 12 and in the Unit 3 Reactor building on March 14, and released a large amount of radioactive material. On March 12, an evacuation directive was announced to people within

*Yoichiro Hosokawa: Department of Radiological Life Sciences, Graduate School of Health Sciences
66-1 Hon-cho, Hirosaki, Aomori 036-8564 Japan
E-mail: hosokawa@cc.hirosaki-u.ac.jp

Table 1. Measurement manual prepared by the Nuclear Safety Commission of Japan and distributed by the Nuclear Emergency Response Headquarters in Fukushima

1. Summary
The purpose of this measurement method is to easily survey the radioactivity inside the thyroid.
2. Measurement Subjects
Children of ages one to fifteen
3. Usable Measuring Instruments
Scintillation survey meter made by Aloka
Model: Limited to TCS-161, TCS-171, and TCS-172
4. Measurement Conditions
1) The survey meter should not make any sound when measuring.
2) The time constant should be set to 10 seconds.
3) Identified values should be able to be in μSv/h units.
4) A measurement should be performed for 30 seconds, after which three measurement values should be taken and the average value recorded.
5) The probe of the scintillation survey meter should be wrapped in plastic wrap or a plastic bag. As the subjects to be measured are children, clean tissue should be wound around the plastic wrap or plastic bag to reduce their fears.
5. Background Measurement
1) The background value should be measured immediately before a thyroid measurement, and this background value should be recorded.
6. Measurement of the Thyroid
1) The neck should be wiped with a sterile towel to be decontaminated. Water to be used in this step should come from an unopened PET bottle.
2) The radiation dose of the thyroid should be measured by attaching a probe to the thyroid. The probe should be attached to the center of the body axis at a height near the intersection point of the neck and the clavicle.
3) An identified value of the thyroid should be recorded, and the background measurement should be subtracted from the identified value to calculate the net value.
4) When a net value is 1.0 μSv/h, residual radioactivity in the thyroid is approximately 22 kBq. This value is that of a one-year-old child, and the value decreases with age.
5) The net value should be recorded along with the subject's residential address and evacuation route.
6) When a net value of 0.2 μSv/h or less is found, there will not be a problem.
7) If the background measurement is more than 0.2 μSv/h, it will be difficult to obtain the accurate data in this method.

a radius of 20km from the nuclear power plants and then almost all of the residents evacuated[1].

On March 13, Radiation Safety Council at Hirosaki University was organized to discuss responses to this accident. At the request of the Ministry of Education, Culture, Sports, Science and Technology, the council decided to dispatch university staff to Fukushima to support the people living there. Survey teams were organized on a weekly basis and took turns going to Fukushima to carry out screening tests of radioactive contamination on the residents on the spot[2]. The main task in March, 2011 was to carry out the surface radioactive contamination surveys on evacuating residents at evacuation centers set up within a radius of 20-30 km from the nuclear power plants. During this time it was announced that some areas beyond the 30 km radius showed high radiation doses , according to a trial calculation by a SPEEDI (System for Prediction of Environmental Emergency Dose Information)[3]. In order to estimate the health effects on children, the Nuclear Emergency Response Headquarters, at the request of the Nuclear Safety Commission of Japan, implemented thyroid screening surveys on children, ages one to fifteen, in Iwaki City, Kawamata-machi and Iitate Village from March 24 to 30. In this study, as we were included in these thyroid screening surveys, we will provide a summary of the surveys.

2. Method

Radiation dose in the thyroid was measured in accordance with the manual prepared by the Nuclear Safety Commission of Japan and distributed by the Nuclear Emergency Response Headquarters[4]. The main points of the measurement manual are shown in Table 1. We estimated radiation doses following these methods of the measurement manual.

3. Results

Although thyroid surveys were performed May 24-30, most of them were carried out on March 29 and 30. The total 560 cases analyzed by the Hirosaki team on March 29 and 30 are included in the 1,080 cases, done up to May 24-30, which were reported by the support Team for Residents Affected by Nuclear Incidents. Our Hirosaki team measured radiation doses in thyroids on 258 people at the Kawamata-machi Public Citizens' Hall on March 29, and on 302 people at the Iitate Village Office on March 30. The situation at the Iitate Village Office on March 30 is reported here.

The outdoor air dose rate in Iitate Village reached 7.3 μSv/h and the dose rate exceeded 0.2 μSv/h in almost all places in the Iitate Village Office before the screening survey at 9 AM on March 30. Therefore, we looked for a place where the contamination level was the lowest and there had been the least amount of people. Finally we decided upon the test area behind the chairman's seat in the village council room (test room) because the air dose

Fig. 1. Circumstances of the surface contamination survey before the thyroid test in Iitate Village
Before they entered the test room, it was ensured that the radioactivity of the participant surface would be less than 1000 cpm in order to prevent the increasing of radiation dose in the test room.

Fig. 2. Circumstances of the thyroid survey in Iitate Village
Measurement was performed for 30 seconds by attaching a probe to the child's thyroid and values were then read three times. The average value was recorded. The background value was subtracted from the average value.

rate around there was 0.1 μSv/h.

Before thyroid screening survey, we performed a whole-body surface survey of all participants at the reception in order to prevent the increasing of radiation dose in the test room. We allowed them to pass at the reception after their measurement value was confirmed less than 13,000 cpm. 13,000 cpm is the standard level of whole-body surface survey according to the Nuclear Safety Commission of Japan and the Nuclear Emergency Response Headquarters. It is based on this radioactive contamination value of surface corresponding to 100 mSv achieved in the thyroid of children[5]. If the value was over 13,000 cpm, we instructed partipants to take off jackets or sweaters and checked again.

Furthermore, we checked them to ensure their measurement values under 1,000 cpm at the entrance to the village council room for children receiving a thyroid survey and caretakers as dose rate of the village council room would not exceed 0.2 μSv/h. IAEA defines that contamination shall mean the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm^2 for beta and gamma emitters[6]. We suggested 1.000 cpm as equivalent 0.4 Bq/cm^2 on surfaces. As a result of these procedures, we could measure all children who wanted to receive the thyroid survey and the air dose rate in the village council room had not exceeded 0.2 μSv/h. The condition of a whole-body surface survey is shown in Figure 1.

For the survey, the probe of a scintillation survey meter was attached to the thyroid as described in the manual (Fig. 2). A radiation dose was measured for 30 seconds. Three measurement values on the same children were read and the average value was recorded. The dose of the front part on the shoulder as a background was read three times in the same way, and the average of the three values was recorded. A net dose in the thyroid was determined by subtracting the average value of the shoulder as a background from the average value of the thyroid. In Iwaki City, Kawamata-machi and Iitate Village, 1,149 persons were examined by all teams of The Nuclear Safety Commission of Japan from May 24 to 30. Measurement results of 66 persons could not be accurately obtained because the environmental radiation dose was higher than 0.2 μSv/h, and ages of 3 persons were unknown. These 69 persons were excluded, and the results of remaining 1,080 persons were announced by the medical group of the Support Team for Residents Affected by Nuclear Incidents[4]. The graph of the results is shown in Figure 3. The highest measured value was 0.1 μSv/h. The values less than 0.01 μSv/h accounted for 55.4%, and these equal to or less than 0.04 μSv/h for 99.0% of the total.

4. Discussion

The increase of thyroid cancer is recognized as an effect of the Chernobyl disaster. Assuming that the World Health Organization's estimate of nearly 5000 cases of radiation-related thyroid cancer occurred after internal exposure to Chernobyl fallout, a 1% disease-specific mortality over 25-30

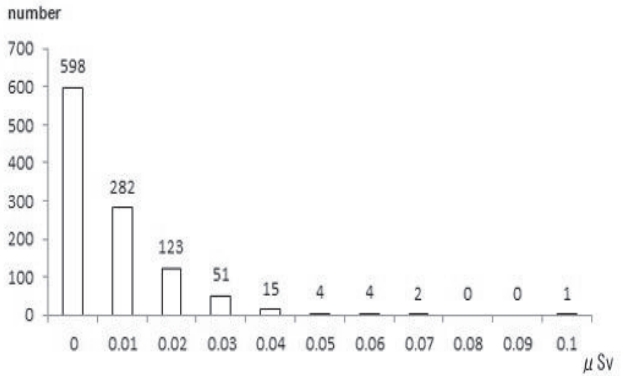

Fig. 3. Results of measuring 1,080 persons by the thyroid screening surveys, reported by the medical group of the Support Team for Residents Affected by Nuclear Incidents.

years would equate to about 50 deaths directly attributable to thyroid cancer[7]. It is considered that the increase of thyroid cancer in the Chernobyl district was caused by ingestion of ^{131}I from foodstuffs[7]. Artificial radionuclides such as ^{133}xenon, ^{131}iodine, ^{134}cesium, and ^{137}cesium were released from the reactor buildings into the environment after the nuclear accident in Fukushima[8]. The scattering of radioactive materials was influenced by the wind direction, the weather and geographical features, and did not spread concentrically. It is considered from the investigation by the SPEEDI that radioactive plumes were released from Unit 2 on March 15, and fell onto a large area to the northwest[9].

Among the teams assembled at the Nuclear Emergency Response Headquarters in Fukushima from March 24 to 30, those having a scintillation survey meter moved to these places and measured radiation dose in the thyroid. Radioactivity had to be measured by a simple and easy method because we needed to make haste in a state of chaos after the great earthquake. It is suggested that this measurement method is based on the experimental results of Tanaka and Kawamura[10]. Taking into consideration the ages of children, they prepared thyroid phantoms of different sizes. Already-known ^{131}I was enclosed in the thyroid part of the phantom, and they measured radiation dose externally with a scintillation survey meter. According to this method, it is assumed that 2.864 kBq of ^{131}I has accumulated in the thyroid when the measured value is 0.2 μSv/h.[10] On the other hand, value of 3 kBq ^{131}I gives 100 mSv equivalent dose in thyroid and carcinogenesis increases significantly with an equivalent dose of 100 mSv or more[11]. We suggested that the problem dose rate level (0.2 μSv/h) pointed out with the manual is based on this theory. The method of Tanaka and Kawamura can be used when only ^{131}I is measured[10]. Several kinds of radioactive material (^{131}I, ^{132}I, ^{133}I, ^{134}Cs, ^{136}Cs, ^{137}Cs, ^{132}Te, and ^{133}Xe) were scattered into the air by the Fukushima Nuclear Power Plant Accident[8]. The main problem in the current survey is that the effect of other radioactive materials is unknown as a gamma spectrum was not analyzed. In the current method, this problem is compensated by simply subtracting the background measurement.

In the results of the current screening survey method, the highest measured value in the thyroid is 0.1 μSv of effective dose. Given the abovementioned theory, it is conceivable that thyroid equivalent doses did not reach 50 mSv. Suzuki reported that the maximum thyroid dose of this survey method was evaluated as 35 mSv[12]. For this dose calculation, it was assumed that the radioiodine was continuously inhaled from March 12 to March 23. Tokonami et al. estimated the highest value of equivalent doses at 33 mSv in the thyroids of 62 persons from 0 to 83 years old living around the Fukushima Nuclear Power Plant (45 people evacuated form coastal area and 17 residents in Tsushima district) when they analyzed a spectrum of radioactive ways[3]. Brenner et al. reported the statistical correlation between exposed doses of thyroids and cancer occurrence rates from an analysis of Chernobyl disaster[13]. However, even in their report, a conspicuous increase was not observed in the case of a value of less than 100 mSv. Therefore, inferring from the current results, it is quite unlikely that thyroid cancer will rapidly increase in Fukushima. However, we might need to analyze spectrum of thyroid which showed high radioactivity value on this survey. In order to verify this, thyroid tests on children who seem to have been exposed to low-dose irradiation should be continued[14]. This result will be referred to for a long time as thyroid doses in a large number of children were measured about 30 days after the Fukushima Nuclear Accident. As these measurements are expected to be verified in the future, the measurement method is documented in this paper.

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