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Technique Development for Appropriate Understanding and Promotion of Radiation Risk

Yukihiko Kasai

Aomori Prefecture accommodates many nuclear power plants, their related nuclear facilities, and planning institutions, where their construction is planned, and is particularly emphasized in the New National Energy Policy. It is necessary for these nuclear facilities to satisfy the national safety standards, be at a safe location, and be operational. However, after the Fukushima Daiichi Nuclear Power Plant accident followed by the Great East Japan Earthquake on March 11, 2011, the general inhabitants became anxious and questioned their safety. Their concerns included, are the nuclear facilities in their areas disaster proof? and what will happen if a nuclear accident occurs? Not only the general inhabitants but also the firefighting staff had doubts and/or concerns against nuclear power disaster and nuclear accident. Therefore, it is necessary for the firefighting staff to acquire sufficient knowledge on radiation by attending lectures or training courses on radiation exposure medical care.

This study examined the following issues: How does the firefighting staff perceive radiation? What are their doubts and concerns? To know how much they understand radiation, "a questionnaire survey about radiation" was administered to the staff of 5 of 11 firefighting headquarters in Aomori Prefecture. Fortunately, more than 1,000 responses were obtained and analyzed. Results of the questionnaire survey were compared between the general inhabitants of the urban area in Aomori Prefecture and the inhabitants who evacuated from Namie town, Fukushima Prefecture, to other areas. The firefighting staff's tendency to understand radiation was analyzed.

As a result, it was found that there were many firefighting staff member with an incorrect understanding of basic radiation exposure. In addition, many of them recognized that radiation effects were evident even the exposure was relatively low and the main effect was "cancer", but the recognition of other effects was low. Furthermore, the extent of understanding was also found to be low in most participants.

These results might be helpful when considering the contents of future lectures or training courses on radiation.

Radiation Dosimetry Combining ESR and Granulated Sugars Irradiated with Low Doses of X-rays and its Application to the Teeth of Field Mice in Fukushima

Taichi Kitaya

Electron spin resonance (ESR) spectroscopy in combination with certain irradiated solids is a known method for measuring radiation doses. In the present study, the combination of ESR and granulated sugars exposed to low doses of X-rays (0–2000 mGy) was first examined to confirm the validity of this method. This method was then used to measure the accumulated radiation doses in the teeth of field mice living around the nuclear power plant in Fukushima.

Four hundred mg of glycine powder containing 5.0×10^{13} spins of 1,1-diphenyl-2-picrylhydrazyl (DPPH) was used as a standard to estimate the amounts of free radicals in both the irradiated sugars and the teeth of field mice. After the granulated sugars (400 mg for each) were subjected to X-ray doses of 0–2000 mGy, ESR signals were obtained by tracing an 18.4-mT magnetic field for 3.6 s and repeating this process 100 times using a JEOL JFS-RE1X ESR spectrometer; the ESR conditions were 1 mW of microwave power with 9.08-GHz field modulation of 0.4-mT amplitude. After the background ESR signal of non-irradiated sugar was subtracted from each ESR signal, the resulting signal was doubly integrated using the WINRAD computer software (Radical Research Company, ver. 1.20) to convert the signal into intensity. The amounts of free radicals in X-ray-irradiated sugars were calculated by comparing the doubly integrated values of the ESR signals of irradiated sugars with the corresponding values of the DPPH standard.

A linear relationship between the amount of free radicals and irradiation dose was obtained for doses in the range of 0–2000 mGy. The applicability of ESR spectroscopy as a dosimeter was certified in the dose range of 33 mGy or greater. On the basis of the slope of the straight line, the efficiency of free-radical production in granulated sugars per 1 Gy irradiation was estimated to be 2.1×10^{14} /g/Gy. This method was then used to measure radiation doses accumulated in the teeth of field mice living around the nuclear power plant in Fukushima. Nineteen field mice were collected between November 15 and 17, 2013. ESR signals of the teeth (40 mg for each) were obtained by repeating the ESR measurements 20 times under the same conditions previously described. The teeth of field mice collected in Hokkaido were used as non-irradiated control samples. Because the control samples gave large background ESR signals, a statistically significant difference between the teeth of mice collected in Fukushima and those of mice collected in Hokkaido was not clear.

Major Sources of Tritium in the Environment and Radiation Dose Assessment Result Survey Caused by the Discharge of Tritium

Kazuki Kubo

[Introduction]

Tritium is a radioactive isotope of hydrogen. It is one of the radionuclides that is released into the environment from nuclear facilities. However, establishing separation techniques to quantify such radionuclides is difficult. The tsunami that occurred following the March 11, 2011 Great East Japan Earthquake damaged the Tokyo Electric Power Company Fukushima power plant. Tritiated water has continued to accumulate at the power plant site. Appropriate processing methods for this tritiated water are also problematic. It is very concerned about tritium.

This study focuses on the nature and behavior of tritium in the environment and its influence on the human body. The objective is to improve scientific expertise related to tritium.

[Major sources of tritium in the environment]

Tritium occurs naturally in the environment. Other sources of tritium in the environment are nuclear weapons testing, nuclear facilities, medical and industrial applications, and scientific research. In this study, tritium of nuclear experiment origin, the largest contribution among them, and the tritium due to the nuclear facility that has been growing current interest was investigated and was organized the contents.

[Tritium dose assessment results survey]

Tritium dose assessment survey focused on tritium from artificial origins. The results were compared and discussed. Given assumed conditions and the focus on the influence on the human body, the numerical value of the dose was compared. The following sources of tritium were assessed:

- Nuclear weapons testing (atmospheric nuclear weapons testing)
- Nuclear power plant (under normal conditions)
- Rokkasho reprocessing facility (under normal conditions)
- Sellafield reprocessing facility (under normal conditions)
- Chernobyl nuclear power plant accident
- Tokyo Electric Power Company Fukushima nuclear power plant accident

The global average annual effective dose of tritium from nuclear weapons testing is approximately 10 μSv / year at most; the impact on people is very small. The concentration of tritium in stagnant water at the Tokyo Electric Power Company Fukushima nuclear power plant was surveyed in published reports. In addition, exposure dose of the general adult public who drinks tritiated water of the regulated concentration limits over a period of one year was calculated. The calculated result was $6.5 \times 10^2 \mu\text{Sv}$ / year, which is less than the effective dose limit of 1 mSv / year prescribed by Japanese law. The influence of tritium from the other sources was also confirmed to be sufficiently low.

Study of Fractionated Exposure Using Hyper-radiosensitivity for Application to Radiation Therapy

Shingo Terashima

Enhanced cell lethality, also known as hyper-radiosensitivity (HRS), has been reported at low doses of radiation (0–0.5 Gy) in various cell lines and is expected to be an effective cancer therapy using HRS. It is necessary to study hyperfractionation in order to improve radiation therapy. However, the method of exposure using HRS is not established because the dose involved in HRS is too low for clinical application. We conducted this study to examine the effect of low-dose fractionation exposures with a short-time interval for clinical application. We evaluated the cell-survival rate of Chinese hamster V79 cells and human lung A549 cells using colony assays. We performed fractionation exposures in unit doses of 0.25, 0.5, 1.0, and 2.0 Gy. First, we exposed the cells to 2 Gy of X-rays at dose rates of 1.0, 1.5, and 2.0 Gy/min at 1-min intervals by fractionated radiation. Next, we exposed these cells to the radiation dose rate of 2.0 Gy/min at 10-s, 1-min, and 3-min intervals by fractionated radiation. Finally, the total doses of 2, 4, and 8 Gy were given by fractionated radiation at a dose rate of 2.0 Gy/min for 10 s. Apoptosis and cell cycle were also evaluated in fractionation exposures and compared with single exposure. Both cell survival rates with fractionation exposure using a unit dose of 0.25 Gy were remarkably low compared with those of a single exposure delivering the same dose. When the dose rates were lower (1.0 and 1.5 Gy/min), the cytotoxic effect decreased compared with exposure to a dose rate of 2.0 Gy/min. Significant cytotoxic effects were observed when A549 cells were exposed to low-dose fractionation (0.25 Gy \times 8) using 10-s, 1-min, and 3-min intervals compared with single exposure. On the other hand, the cytotoxic effect decreased when V79 cells were exposed to low-dose fractionation (0.25 Gy \times 8) at 3-min intervals, compared with shorter time intervals (10 s and 1 min). When cells were exposed to total doses of 2, 4, and 8 Gy by fractionated radiation at the unit dose of 0.25, cytotoxicity was enhanced as the total dose increased up to 8 Gy. These results indicate that a more effective cell death is induced with low-dose fractionation exposures for a given dose due to the HRS phenomenon, thus suggesting that a dose rate was important for effective low-dose fractionation exposures.

Influence of Radioactive Iodine Released to the Environment

Megumi Hattori

The release of radioactive materials to the environment causes anxiety among the general population. To prevent mental harm due to this anxiety, understanding the influence of radiation is important.

To clearly explain the influence of radioactive materials released to the environment to a lay person, a literature search was performed. Attention was particularly given to radioactive iodine, whose insufficiently high doses can cause thyroid cancer.

First, outlines of typical incidents and accidents, including nuclear tests, medical accident, accidents in nuclear power plants, and an atomic fuel reprocessing institution, with the release of radioactive iodine were completed.

Next, the general numerical value of the release amount and the dosage of the radioactive iodine were calculated using the methods documented in the UNSCEAR reports. These methods, which are the trial calculation of the average annual doses, are suitable for determining and comparing dose levels as well as assessing the risk to the general public. Thus, the calculated result described here should be used in other applications only with caution, and site-specific data should be used where appropriate.

The biggest release source of ^{131}I to the environment was atmospheric nuclear tests performed from 1945 to 1980, and the practical effective dose of ^{131}I that the public received due to these tests was an average of 1.85 $\mu\text{Sv}/\text{year}$. In contrast, the release amount of radioactive iodine from the Fukushima nuclear accident was 1/1000 that of atmospheric nuclear tests and approximately 1/10 - 1/3 that of the Chernobyl nuclear plant accident. The influence of the released amount of radioactive iodine from the Fukushima nuclear accident on thyroid was likely sufficiently low.

The dose of ^{131}I released from a reprocessing institution that the public received over a period of one year was calculated to be approximately 1/100,000 that of nuclear tests.

The dose level of radioactive iodine calculated from actual release amounts from the Rokkasho reprocessing plant, which is expected to continue operation in Japan, could be lower than the set dose limit. Considering safety precautions undertaken in the design of a factory, it is inferred that the actual dose is lower than the dose limit, which is estimated from a worst-case scenario.

The Scattered Radiation Measurement of the Portable Device

Hideyuki Nishimura

The Aomori where we belong to Prefectural center Hospital is appointed to the second emergency radiation exposure medical institution. The acceptance measures room is done with the urgent radiation exposure medical care manual with a waiting room of the radioisotope examination room under the ground and I set it at one time in the management area after arranging equipment of the injection room, and having put good self-care and am to accept you.

It is past, and we experience RADIATION EMERGENCY MEDICINE in joint training with the Tohoku Electric Power Higashidori nuclear power generation relations staff, Natl. Inst. of Radiological Sci. (NIRS) radiation accident first action seminar and United States Tennessee REAC/TS.

I perform the decontamination of a verge pollution point taking urgent radiation exposure medical care in the urgent radiation exposure medical care training in these training until I fall down to the Buckland level, but the assumed injury is a bone fracture to be accompanied by the lacerations of the lower limbs by the workmen's accident accident by the whole periodic inspection work in the atomic energy. I carry out X-rays simplicity photography with a radiography device (portable device) for rounds to confirm a bone fracture state to give medical measures after decontaminating it and will diagnose it.

I avoid the overreaction for the radiation dose of the X-rays simplicity photography to use for medical care (when I photograph Portable in a ward, medical staff may move to the remote place of the considerable distance). I can avoid an unnecessary radiation exposure dose of radioactivity of the team staff by knowing the radiation dispersion dose of radioactivity level.

When I set up a management area at one time this time in the radioisotope examination room preparations room of our House under the ground, 150 cm is the greatest distance that left it. The dispersion doses of radioactivity were almost less than $1\mu\text{Sv}$ by "a law of the reverse square of the distance" at distance 150 cm on chest photography condition (pipe voltage 80 kV, pipe electric current 10 mAs, irradiation field 35 cm \times 35 cm).

Problems in Radiation Emergency Medicine during the Fukushima Daiichi Nuclear Accident and Suggestions for Improvement

Naoki Akimoto

The Great East Japan earthquake on March 11, 2011 caused extensive damage by tsunami and nuclear hazard in the Fukushima prefecture, which necessitated radiation emergency medicine. In Japan, a system of medical treatment for radiation exposure was formed after the Tokaimura nuclear accident on September 30, 1999. Several medical institutions were classified into three categories, according to the required treatment and were appointed to treat patients. However, many problems were encountered in the actual site of emergency medical treatment for radiation.

To improve these problems, we collected and studied reports on the Fukushima nuclear accident. First problem was insufficient technical skill of medical staff; they had no idea what to expect and were not trained enough for the actual scenario. Consequently, they treated patients while referring to manuals. Second problem was the difficulty in moving patients who were in the hospitals near the Fukushima I Nuclear Power Plant. They needed emergency evacuation, but there were few institutions they could move and they were made to wait long time on the buses. During transit, over 20 patients died from their primary illness. Third problem was the gap in communication. The medical staff were supposed to render treatment based on the command from the management center of Fukushima nuclear hazard, but they could not communicate with the center. Additionally, there were many problems on the actual disaster site.

We organized the problems in three categories. First, they did not consider complex disaster. Second, they did not prepare sufficiently for disaster in usual times. Third, they did not educate people from regions that were considered not to be impacted by radiation exposure. As a result of these, we must perform two countermeasures. One of them is to assume that a complex disaster can most likely occur; hence, perform disaster drills in a practical manner. Another is to educate people all over Japan on basic treatment for radiation exposure.

Occupational Exposure of Nurses during Decontamination Work in Rooms Containing Unsealed Radiation Sources

Chieko Itaki

The present study aimed to determine the occupational exposure of nurses during decontamination work in rooms containing unsealed radiation sources. We also measured the ambient dose rates in hospital rooms after patients underwent unsealed radiation source therapy.

The subjects were nurses occupationally exposed to rooms containing unsealed radiation sources during decontamination work and the ambient dose rates in hospital rooms after patients underwent unsealed radiation source therapy. The nurses wore a dosimeter when they performed decontamination work. The dosimeters measured the time spent performing decontamination work and the radiation dose. The same dosimeters also measured the accumulated dose. Beta rays in the hospital room at bathroom were measured using a GM survey meter.

The nurses' occupational exposure was $0\mu\text{Sv/h}$. The dose was the highest at the washbasin drain outlet for 5 points. The trash was a dangerous source because it included radioactive iodine on the brim as well as in sputum and nasal discharge. Radioactive iodine dosing was measured, where radioactive substances were present. Accordingly, nurses need to be careful when handling trash to avoid external exposure. In other words, decontamination work should be performed in short periods of time.

Improving the Emergency-preparedness of Aomori Prefectural Central Hospital to Treat Patients Exposed to Radiation

Hiroki Odaira

Aomori Prefecture, located in eastern Japan, is home to the Higashidori Nuclear Power Station, operated by Tohoku Electric Power Co., Inc. In March, 2004, the prefectural government published an emergency medicine manual addressing treatment of radiation disaster events. In June 2008, Aomori Prefecture revised the manual's guidelines concerning treatment for inhabitants exposed to serious radiation contamination from nuclear facilities. In it, Aomori Prefectural Central Hospital was designated as a secondary radiation emergency medicine facility.

Following the Great East Japan Earthquake in 11 March 2011, Japanese people have shown an increased interest in the risk of radiation contamination, and in facilities that use radioactive material. Currently, the Aomori Prefecture plans to target Aomori Prefectural Central Hospital to accept radiation-contaminated patients requiring emergency treatment. However, the hospital is not sufficiently prepared to provide adequate radiation emergency medicine services. The present study investigates the hospital's preparedness to provide both emergency and radiation disaster medicine services.

The Japanese government conducts annual national disaster preparedness training in cooperation with local public entities. Aomori Prefectural Central Hospital participated in training conducted in October, 2013. The results demonstrated that the hospital is ill-prepared to provide sufficient radiation emergency care for the four anticipated radiation-contaminated patients. In particular, the hospital's Radio Isotope (RI) ward (a sealed-source ward for treating nuclear accident casualties), is not intended to be available until needed.

Until March 2014, Aomori Prefectural Central Hospital stocked minimum quantities of medical equipment and drugs for the RI ward. Since April 2014, the ward has been closed. If there are no inpatients, a hospital staff member is assigned to the ward during the day, and no one is assigned to it at night. Consequently, the hospital cannot respond quickly to radiation emergencies. As such, it fails to adhere to the principle that emergency medicine "delivers the highest quality medical treatment, anytime, anywhere." Because the RI ward is not always equipped to serve patients, the hospital also fails to apply the guiding principle of disaster medicine: "the greatest advantage for the greatest number. RI ward is not suitable to receive patients.

Excluding the RI ward, the Emergency Center of Aomori Prefectural Central Hospital is the best candidate to provide treatment for radiation exposure and radiation disaster events.

Importance of Information Sharing on Radiation Dose for Adequate Management of Medical Assistant Team in Nuclear Disasters

Masaru Ogasawara

Large scale and complex disasters; including nuclear accidents, entail evacuation of a large population comprising tens of millions of people. It could be expected to take several days for such large scale evacuation. In particular, individuals such as inpatients and people living in nursing homes are vulnerable when disaster strikes and they may face the risk of death by involved in a traffic jam without medical care for a long time. In the event of a nuclear disaster, it is necessary to ensure that an adequate number of medical response teams are deployable to secure safe transport of patients, staff, and equipment to an alternative location. Therefore, in the present study a questionnaire survey was carried out to investigate awareness for a radiation emergency medicine among 733 disaster medical assistant teams (DMATs) who were designated by medical institutions nationwide. Many of the teams that were hesitant to serve on the frontline declared their willingness to be deployed if other teams have already measured the radiation dose. This suggests the importance of timely sharing of information on radiation dose to ensure that a sufficient number of medical response teams are deployable. Although some teams are equipped with a conventional dosimeter, it is unlikely that it will be designated as a standard portable device for DMATs due to various issues such as cost, maintenance, and size. Many teams showed great interest in the ultra-compact dosimeter instead.

As we experienced in the wake of the Fukushima Daiichi nuclear disaster, detailed data by measurement of air dose rate was not obtained in the aftermath of the disaster when confusion still prevails. Although a DMAT uses Emergency Medical Information System (EMIS) to share various types of information on radiation dose, it may take a considerable number of days for the group to receive data compiled by other institutions. In addition, it is expected that during the first few days following the disaster, there may be only a few locations available for captured data. It is difficult for the DMATs to decide whether they should serve in the frontline because of uncertainty in measurements of air dose rate and risks for radiation exposure; therefore, it is likely that they will decline. By the time the data is made available, intervention by medical personnel may not be needed anymore. Certainly, the safety of medical response teams must be a priority. Yet, timely sharing of data on radiation doses is crucial to facilitate swift hospital evacuation and, simultaneously, to ensure the safety of medical response team members. Data exchange among medical response teams would enable more precise measurement of radiation levels, but compilation of analogue data will require much time and energy.

As part of this study, we also evaluated the usefulness of a new ultra-compact portable dosimeter on a trial basis in the Fukushima Prefecture. Once connected to a smartphone, the device works in conjunction with an application software and continues to take and store measured results automatically as digital data. It is also possible to visualize the measurements by automatically importing them to an enlargeable map for real-time information sharing. We concurrently used conventional dosimeters to capture data for comparison. The figures were more or less the same and credible; it was believed that the new device could appropriately replace the older one.

As the discussion above attests, information dissemination on correct knowledge of radiation and timely sharing of data on radiation doses are required to ensure that enough medical response teams are deployable in the event of large scale and complex disasters.

The Effect of Crystalline Lens Radiation Exposure Reduction on CT Examination and CTDI Inspection

Shogo Sakata

In an April 2011 statement, the International Commission on Radiological Protection announced that a switch from an annual 150-mSv crystalline lens radiation dosage safety limit should prevent exposure over an average period of 5 years from exceeding 50 mSv and 20 mSv in a single year. The crystalline lens is rarely an examination target, but incidentally this often provides incoming radiation during computed tomography (CT) examinations of the head and neck and, incidentally, the temporal bone. This study aimed to determine the effect of crystalline lens radiation exposure reduction when using ODM, ASiR (40%), and the Bi shield as dose-by-dose reduction measures during head CT examination and to conduct a comparative inspection of the computed tomography dose index (CTDI) indication level on the CT console when using radioactivity dose reduction measures and measured values. I measured head images according to time and while using each reduction measure along with a TLD element to evaluate the radiation exposure dose of the crystalline lens as well as the SD and CT levels at the eyeball and temporal lobe in the images. When using ODM, the crystalline lens radioactivity dose reduction rate ranged from 11%–15% and the images did not differ significantly from those collected under normal time conditions. With ASiR (40%), the crystalline lens radioactivity dose reduction rate ranged from 37%–39%, the image SD levels increased by approximately 1.0 in both areas, and a change was observed in the CT level. However, the artifactual phenomena were not acceptable and could be ignored at the clinical level. When ODM and ASiR (40%) were combined, the crystalline lens radioactivity dose reduction rate was 37%–39%, an effect similar to that achieved with the Bi shield. SD levels of the eyeball significantly increased while using the Bi shield, but the image obtained while using ODM and ASiR (40%) in combination hardly differed from that obtained with ASiR (40%) alone. Therefore, I think that the combined use of ODM and ASiR (40%) is an effective CT device reduction measure. The CTDI measurement experiment measured the central area of the phantom as well as 5 points (top and bottom, right and left), and these measurements were averaged. The measurements decreased at the center and upper points when using ODM and overall when using ASiR (40%). The CTDI indication level on the CT console decreased similarly to the measured value. The measurements obtained while using ODM and ASiR (40%) in combination increased by approximately 8.2%–9.0% relative to the measured values and indication level. Similar relative errors were obtained under all conditions with regard to ODM and ASiR (40%), suggesting that the changes in the CTDI indication levels on the CT console were appropriate.

This study suggested that ODM, ASiR, and the Bi shield were useful radiation exposure reduction measures.

Statistics on the Victims of Radiation Exposure in Aomori Prefecture: Problems and Countermeasures during Field Activities

Akira Numayama

The aims of this study were 1) to conduct a survey on awareness and the transport system during the radiation disaster in Aomori Prefecture and 2) to analyze the difficulty of information transfer after the Great East Japan Earthquake and the accident at Fukushima Daiichi Nuclear Power, March 11, 2011, from the standpoint of “problems and countermeasures during field activities for numerous patients exposed to radiation in Aomori Prefecture.”

In particular, the study analyzed the following three points:

1. Results of an exposure awareness survey among the participants of the medical courses on the Aomori Prefecture disaster.
2. The situation with deployment of capital equipment by burn units of a neighborhood fire department.
3. Research on the medical care administered in transport vehicles.

At present, each agency is conducting a variety of activities and training programs on the measures taken in response to a complex radiation disaster. Even if there is a lack of personnel immediately after the disaster, problems with availability and delivery of capital equipment are likely; thus, an ideal emergency response to the disaster was difficult due to many uncertainties.

The personnel and capital equipment are also necessary during a radiation disaster. Emergency management is quite limited if the capital equipment cannot be used properly in case of a disaster such as the Great East Japan Earthquake. Furthermore, in cases where the tissue in direct contact with radioactive material is lost, suitable therapeutic measures have yet to be determined in the affected geographic areas, during active emergency management.

On the basis of the survey of the literature and of the participants of the medical course on the Aomori Prefecture disaster as a result of the first nuclear power plant accident in Fukushima TEPCO, we discussed the current medical response to radiation exposure and the initial response to the problems during a complex disaster. The surveys and research were conducted to devise therapeutic procedures applicable during transport of victims of radiation exposure. We can conclude that there is a need for greater awareness of the radiation disaster in Aomori Prefecture.

A New Method for Expressing Radiation Exposure by Means of Area in a Chart

Minoru Osanai

A chart showing the medical exposure dose, the natural radiation dose, and the relationship between radiation exposure doses and influence on the human body has been used for explaining radiation injuries to the public. Currently, a logarithmic axis is used as the longitudinal axis which scales a radiation dose in most of the charts. However, the use of a logarithmic axis makes it difficult for the public to understand a radiation exposure dose. It is important that a chart allows the simple and accurate portrayal of the radiation dose to the public.

We devised a new method for expressing the radiation exposure dose by means of a chart area for the purpose of easier public understanding. We performed a questionnaire survey to evaluate the new method. In the survey, we investigated how subjects recognized each radiation exposure dose of computed tomography (CT), positron emission tomography (PET), and chest X-ray examinations in a chart prepared by the traditional method or the new method in which a visual analog scale is used. The subjects estimated smaller radiation exposure when studying the chart prepared by the new method as compared with that when studying the chart prepared by the traditional method. However, estimated radiation exposure doses recognized using the new method were closer to true values, indicating that the logarithmic chart gave the impression of exaggerated radiation doses. Because of the large change of scale in the logarithmic chart, an interval of two plots may be very close, leading to the interpretation of larger radiation doses in the logarithmic chart. Additionally, the degree of anxiousness caused by exposure with CT, PET, and chest X-ray examinations were investigated. It is suggested that the type of chart influences the degree of anxiousness caused by exposure experienced by subjects.

In conclusion, it is suggested that the new method for expressing the radiation exposure dose by means of the area in a chart is useful to understand radiation dose correctly.

Method of Estimation of Internal Dose Using Environmental Samples

Taiga Kawamura

On March 11, 2011, the nuclear accident at the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) occurred as a consequence of the massive earthquake and subsequent tsunami that struck East Japan. The accident caused the release of a large amount of radionuclides into the environment, forming radioactive plume. It is reported that the abundance ratio of radionuclides in the soil is different in the North Western and Southern directions.

This study considers the difference of the abundance ratio of radionuclides in the soil using the air dose rate monitoring result data, path of movement of the radioactive plume and rainfall information around the FDNPP, and estimates internal dose using environmental samples.

From the air dose rate monitoring result, it was found that the dose rate in the North Western area was higher than that in the Southern area. Moreover, the radioactive plume reached the North Western area and deposited in the soil. The ratio of iodine and cesium in the North Western area is 3.68 and in the Southern area is 15.2. The difference of abundance ratio of radionuclides in the soil is because of the difference in the deposition of particle matter and gaseous substance. The dry deposition of particle matter is difficult compared with that of the gaseous substance. Furthermore, in the Southern area, there was more rainfall since the arrival of the radioactive plume than that in the North Western area. Therefore, the abundance ratio in the North Western area is higher than that in the Southern area.

In this study, internal doses are estimated; approximately 0.20 mSv effective dose by cesium was found in the North Western area, and approximately 7.43 mSv thyroid equivalent dose by iodine and 0.011 mSv effective dose by cesium were found in the Southern area. In these results, the estimations are close, similar to the result of WBCs for evacuee and residents.

Emergency Medical Response for Radiation in Japan Nuclear Fuel Limited

Hidenori Sugisawa

Safeguarding human life is given topmost priority in case of exposure-to contamination Japan Nuclear Fuel Limited(JNFL). After maximum possible implementation of decontamination and contamination check and the prevention measures for spread of contamination, the victim may be transported to external medical institutions if required. All the necessary provisions are made in the field. Rapid response is required in such cases since the influence of initial treatment in the field is particularly important for life support.

The radiation emergency medical response system of JNFL has been described in the Aomori Prefecture radiation emergency medical manual. JNFL has signed a memorandum of understanding with medical institutions for the medical care of victims of contamination by radioactive substances. Therefore, this system facilitates rapid transport of victims to medical institutions in case of exposure-to contamination. As described in the memorandum of understanding, practical regular training with medical institutions is conducted in JNFL. The aim of this training is to be able to provide rapid and appropriate exposure medical response to victims of exposure to contamination who require to be transported. In this study, the accident at JNFL, was examined from the viewpoints of specific measures and improvements for the JNFL radiation management personnel. These mainly include implementation of education in medical institutions, information transmission during training at JNFL, improvement of how to respond, and information exchanges between institutions. Improvements to the above will result in the formulation of a better training plan that can be implemented in future.

A questionnaire survey conducted on the medical professional development plan for participants and graduates, suggested that education and training should be implemented and agencies should strengthen cooperation by communicating appropriately. This survey enabled the understanding of different perspectives. I was able to grasp the demand from each institution for nuclear facilities at the time of exposure medical response. Therefore, I want also to reflect a desire to JNFL.

Several activities have been planned for the development of medical professionals in future. As such, communication connects the graduates of each institution and our activities are at the forefront in the development of a bottom-up robust system for radiation medicine in Aomori Prefecture.

Difficulties and its Factors for Acceptance of Victims Contaminated with Radioactive Materials, from the Experience in Civil Protection Virtual Practice

Ayumi Abe

Purpose: [A] hospital in Aomori Prefecture is a disaster base hospital and positioned as one of the secondary radiation medical institutions. The Civil Protection Virtual Practice to deal with dirty-bomb case has been conducted in Aomori Prefecture in 2013. Then [A] hospital participated in this practice by using the current manual. A number of problems such as lack of practicality of the current manual, insufficiency of acceptance system for contaminated victims were revealed in this training. In this study, the nursing staffs who participated in the Civil Protection Virtual Practice were interviewed to reveal the difficulties and its factors for accepting victims contaminated with radioactive materials.

Methods: Seven nurses from [A] hospital who participated in the Civil Protection Virtual Practice that took place in Aomori Prefecture, in November 2013 were interviewed. They were interviewed for such as preparations for the training, roles in the training, impressive things, good things, bad things and anxieties during the training. Furthermore flaws of the current manual and proposes for the improvement of the current manual were asked. By recording the interviews, descriptions about difficulties and its factors for acceptance of victims were extracted, summarized and encoded. Descriptions were compared by considering the similarity and dissimilarity of contents and categorized.

Results: As difficulties for acceptance of victims contaminated with radioactive materials, two categories consisting of eight subcategories ([to be unfamiliar situation] [predictable confused situation]) were extracted. Also, as factors for difficulties of the acceptance of victims contaminated with radioactive substances, two categories consisting of six subcategories ([realistic and effective system has not been established] [lack of knowledge, technique, and educational system]) were extracted.

Discussion: If we think about actual scenario of accepting victims contaminated with radioactive materials, the lack of established systems including proper environment and supplies, and the lack of knowledge and technique in staffs for the prevention of radioactive contamination and its expansion must be serious problems. Therefore the construction of systems including proper environment and supplies, acquirement of enough knowledge and technique by staffs though periodic seminars and trainings are crucial. In the end establishment of systems for the worst case is required.

The Influence of Plutonium on the Human Body

Satoshi Sato

In Aomori Prefecture, for the reuse of plutonium, the Oma nuclear power plant with a full mixed oxide furnace and a plutonium reprocessing plant is under construction in Oma Town and Rokkasyo village. For developing an appropriate remedy pertaining to the situation of emergency in the Aomori Prefecture due to radiations from the pluthermal-related facilities, an understanding of the biological characteristics of plutonium, particularly, those of its carcinogenicity is required. Therefore, to examine the influence of plutonium on the human body, we investigated the experiments conducted on human subjects under the Manhattan Project, and the plutonium radiation exposure accidents at Los Alamos during World War II". During the follow-up survey of 26 people involved in the plutonium radiation exposure accident, the occurrence of bone, prostate, bladder, skin cancers were observed, but most of the cancers had more likely occurred naturally. Only osteosarcomas may have been caused by plutonium exposure. Among the people injected with plutonium, 18 had been followed. Because most people already had serious underlying diseases, the available data was not useful. The results of these experiments, however, helps to guide the current plutonium protection systems. Using mice, rats and beagles as animal models, the possibility of a correlation between plutonium and lung and bone cancers was described. After radiation exposure due to inhalation, the exposure was less than the threshold dose of radioactivity, the occurrence of lung cancer was mostly not observed. On the other hand, bone cancer was observed after exposure to a small dose of radiation administered by inhalation or injection. In addition, non-neoplastic diseases such as radioactive pneumonia, pulmonary fibrosis, and decreases in peripheral blood leukocytes were considered to be the deterministic outcome. The biological effects of plutonium vary according to animal species, sex and age at the time of the radiation exposure. It was revealed that plutonium radiation exposure is a risk factor for lung and bone cancer, although lung cancer was mostly not observed when radiation exposure was less than the threshold dose. On the other hand, bone cancer was observed after a small dose of radiation exposure. The risk of bone cancer increased when exposure via injection rather than inhalation occurred. Fatal acute radiation injuries occurred after high doses of radiation exposure. In future, a more practical study such as the identification of the threshold dose of radioactivity for the human body is necessary.

A Study on the Exposure Dose for Patients with a Brain Disease at the Emergency Center Education Program for Professionals in Radiation Emergency Medicine

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According to the report of the International Commission on Radiological Protection (ICRP), an exposure dose is recommended that is necessary and as small as possible to reduce both exposure and the number of exposed people as much as possible (as low as reasonably achievable, ALARA). Measures should be taken to comply with the basic concept of optimization. In practice, however, some of the patients, transported to the emergency center, often require multiple radiological examinations such as portable imaging, computed tomography (CT) scan and angiography. An increase of radiation exposure is a concern for patients. By inserting the thermoluminescent dosimeter (TLD) into a tissue-equivalent phantom, the equivalent dose at each site in the actual test, including the effective dose for the whole body was evaluated. The head dose in the head three dimensions digital subtraction angiography(3D-DSA) analysis was 8.957 mGy, and the dose in the salivary gland was higher than that in the head (11.44 mGy). The exposure range along the body axis during the head 3D-DSA imaging included the cervical area. The parotid gland is because of the short distance to the X-ray tube as compared to the head, showed a high value. According to the total equivalent dose among three test types, the head dose was the highest (49.3 mGy; target organ). This value is lower than the threshold (3 Gy) for temporary hair loss, as proposed in ICRP Publication 59, and radiation failure was considered less likely to occur. The results of calculation of the dose at each site from the TLD dosimeter data showed an effective dose in each examination: head portable imaging 0.06 mSv, head CT imaging 0.84 mSv, head 3D-DSA imaging 0.4 mSv, and total 1.3 mSv. The dose was found to decline sharply in the organs of the trunk because they were away from the range of radiation exposure. With a head X-ray examination, the body area below the sternum does not appear to contribute significantly to the effective dose. In order to perform optimization of ALARA measures as well as radiation dose, because it is necessary to know the exposure dose in each of the X-ray examination, to determine the equivalent dose or effective dose in each body part using a tissue-equivalent phantom. In future, I am planning to evaluate the equivalent dose and effective dose at each site, including imaging of other organs.

Promotion and Education of Correct Knowledge on Radiation for the General Population —As a Tool for Taking Appropriate Action in Emergency Situations—

Daisuke Masuda

Objective: When a nuclear accident occurs, it is important to empower residents in order to take appropriate action. Therefore, it is essential for them to acquire appropriate knowledge. An effective method for teaching the general population about radiation was discussed.

Method: A questionnaire survey was given to residents, healthcare workers, and officers in charge of disaster prevention. It asked about images, doubt, and anxiety related to radiation.

Results: Questionnaire responses were obtained from 562 people. The following remarkable beliefs were identified: radiation is infectious; stable iodine tablets are a cure-all; the effects of stable iodine tablets are not well known; and radiation exposure never disappears from human bodies.

Discussion: The investigation results showed that the general population often misunderstands radiation. It is important for residents to acquire correct knowledge about radiation so that they can take proper action if a nuclear accident occurs. In future workshops, the following subjects should be included as the main contents of the lecture: properties of radiation, radiation exposure, natural radiation, protective measures, biological effects, and the actual situation in nuclear accidents.