2015

Journal of JART

–English edition 2015–

The Japan Association of Radiological Technologists

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Note: The contents of this magazine are those that have been published in JART magazine.

Overview of the Japan Association of Radiological Technologists

The Japan Association of Radiological Technologists, a public interest incorporated association under the jurisdiction of the Ministry of Health, Labour and Welfare, was established in 1947 with the purpose of contributing to the health of citizens through raising the professional ethics of members, improving and furthering the study of medical radiology and medical radiological technology, and enhancing public health.

In light of the startling progress being made in the fields of image diagnostics and radiation therapy where radiological technologists work, it is necessary to stay constantly aware of the latest know-how and technology. JART collaborates with other certification agencies to enhance the capacity of all radiological technologists in general through providing lifelong learning seminars, short courses, academic conferences and numerous other learning opportunities. We believe that such activities constitute our obligation as medical professionals to the general public.

As the only medical profession that has “radiological” in its name, we strive to limit medical exposure, to raise the standing of our profession, and to realize a profession of specialist technologists that can be advertised. And we are committed to promoting services with you all for the provision of safe and secure medical care.

general principles

We will render our services to those in need of health care.

We will act as individual members of a health care team.

We will perform our duties in our field of specialty.

We will continue to study for the benefit of mankind.

We will respect and practice the policy of informed consent.

On Issue of Our English Language Journal

Yasuo Nakazawa (President)

The Japan Association of Radiological Technologists, to commemorate the 120th anniversary of the discovery of X-ray, has issued a selection of articles considered to be particularly useful to radiological technologists throughout the world. These have been selected from the latest contributions to "Journal of JART (JJART) " – the academic journal for radiological technologists in Japan.

The contents of "JJART" have three major features. First, they serve to advertise lifelong education seminars to members in order to provide high quality medical technologies in collaboration with citizens and medical professionals. Second, they comprise articles on clinical radiological technology research that is routinely conducted by members. And third, they comprise articles that are contributed by members and non-members based on medical science and technology. Approximately 30,000 copies of the journal are issued every month.

Now, to give the world's radiological technologists some general idea of the work of their counterparts in Japan, I would like to briefly describe the history of the Japan Association of Radiological Technologists. It was established in 1947 as part of the effort to enact a national examination for radiological technologists. Subsequently, it worked together with the government, National Diet, Japan Medical Association, and the Allied Occupation authorities in forming consent on the national examination. Thanks to the tireless efforts soaked in the blood, sweat and tears of our founding members, the Act on Medical Radiographers was promulgated with the passing of Law No. 226 in June 1951. After that, responding to the needs of the age, the Act on Medical Radiographers was revised in 1968; the Act on Radiological Technologists and the Act on Medical Radiographers underwent partial revision in 1983, resulting in unification of the profession under the present Act on Radiological Technologists. The work of radiological technologists at this time comprised general X-ray examinations, X-ray TV examinations, angiographic examinations, X-ray CT examinations, RI examinations, and radiation therapy. Furthermore, the Act on Radiological Technologists was revised in 1993, making it possible for them to perform MRI examinations, ultrasonic examinations, and non-mydriatic fundus photographic examinations. In 2010, the work of radiological technologists was expanded to include assistance in the image diagnostic interpretation, and explanation and counseling related to radiological examinations. And in April 2015, activities will be further expanded to include intravascular injection of contrast media using an automatic contrast media infusion device, needle removal and stopping of bleeding, lower digestive tract examinations (anal insertion of catheter and infusion of contrast media), anal insertion of catheter and air suction during radiological treatment.

The Japan Association of Radiological Technologists is committed to expanding the work of radiological technologists based on scientific backing. We will continue to introduce the clinical, education, and research achievements of radiological technologists in "JJART" and strive to enhance its contents. I hope that this English language journal will be a useful resource for radiological technologists throughout the world.

History of The Japan Association of Radiological Technologists (JART)

1947

- Establishment of JART (July 13)

1951

- Promulgation of the Act on Medical Radiographers (June 11)
- Authorization for Establishment of the Japan Association of Radiographers (June 13)

1954

- First national examination for Medical Radiographers (May 30)

1956

- Event to commemorate the 10th anniversary of founding, attended by Her Imperial Highness Princess Chichibunomiya

1962

- Event to commemorate the 15th anniversary of founding and 10th anniversary of enactment of the Act on Medical Radiographers, attended by Her Imperial Highness Princess Chichibunomiya

1968

- Promulgation of the Act to Partially Revise the Act on Medical Radiographers (establishment of two professions) (May 23)
- First national examination for radiological technologists

1969

- Renaming as the JART
- Staging of the 4th International Society of Radiographers & Radiological Technologist (ISRRT) World Congress at Tokyo Palace Hotel, attended by Her Imperial Highness Princess Chichibunomiya

1975

- Event to commemorate the 80th anniversary of the discovery of X-rays, attended by Her Imperial Highness Princess Chichibunomiya

1979

- Completion of the Education Center for JART

1983

- Partial revision of the Act on Medical Radiographers and the Act on Radiological Technologists (unification of the professions)

1985

- Event to commemorate the 90th anniversary of the discovery of X-rays, attended by Her Imperial Highness Princess Chichibunomiya
- Staging of the 1st Japan Conference of Radiological Technologists

1987

- General assembly resolution for establishment of the New Education Center and a four-year university

1989

- Completion of the New Education Center (Suzuka City)

1991

- Opening of Suzuka University of Medical Science

1993

- The Act to Partially Revise the Act on Radiological Technologists, and Ministerial Ordinance to Partially Revise the Enforcement Orders (April 28)

1994

- Appointment of the President of JART as the 11th President of ISRRT

1995

- Event to commemorate the 100th anniversary of the discovery of X-ray, attended by Her Imperial Highness Prince Akishinomiya

1996

- Start of the Medical Imaging and Radiologic Systems Manager certification system

1998

- Staging of the 11th ISRRT World Congress at Makuhari

1999

- Start of the Radiation Safety Manager certification system

2000

- "Presentation of the Medical Exposure Guidelines (Reduction Targets)" for patients

2001

- Start of the Radiological Technologists Liability Insurance System

2003

- Enactment of X-Ray Week

2004

- Relocation of offices to the World Trade Center Building in Tokyo

2005

- Start of the Medical Imaging Information Administrator certification system

2006

- Staging of a joint academic conference between Japan, South Korea, and Taiwan
- Revision of the Medical Exposure Guidelines

2008

- Establishment of the committee on Autopsy imaging (Ai)

2009

- Revision to the national examination for radiological technologists
- Launch of the Team Medicine Promotion Conference, with the President of JART as its representative
- Appointment of the President of JART as chairperson of the Central Social Insurance Medical Council specialist committee

2010

- Health Policy Bureau Director's notification concerning promotion of team medicine

2011

- Support activities following the Great East Japan Earthquake
- Staging of an extraordinary general meeting concerning transition to a public interest incorporated association

2012

- Registration of transition to a public interest incorporated association (April 1)
- Event to mark the 65th anniversary of founding and transition to a public interest incorporated association (June 2)
- Renaming as public interest incorporated association JART
- Launch of the Radiological Technologists Liability Insurance System with participation by all members

2013

- Signing of the Comprehensive Mutual Cooperation Agreement on Prevention of Radiation Exposure (September 21)

2014

- Consignment of work to measure personal exposure of residents
- Revision of the Act on Radiological Technologists, Government Ordinance to Partially Revise the Enforcement Orders, and Revision of the Enforcement Regulations (June 25)
- Launch of the radiation exposure advisor certification system

2015

- Event to commemorate the 120th anniversary of the discovery of X-rays

Efforts made by the Japan Association of Radiological Technologists

The Japan Association of Radiological Technologists
Yasuo Nakazawa, President

1. Introduction

At approximately 14:46 on Friday, March 11, 2011, a massive earthquake of magnitude 9.0 occurred, whose hypocenter was about 130 km ESE off the Oshika Peninsula, Miyagi Prefecture. This earthquake caused violent tremors over an extensive area from Hokkaido to Kanto. The great earthquake caused giant tsunamis along the Pacific coast of the Japanese archipelago; in particular, tsunamis which exceeded heights of 10 m caused serious damage to many places in the Tohoku area. The giant earthquake and tsunamis hit the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company (TEPCO), resulting in a nuclear accident involving large amounts of radioactive releases. The Japan Association of Radiological Technologists (JART) has dispatched radiological technologists as radiation specialists to Fukushima Prefecture since March 16, 2011 up to now (as of February 20, 2012) in response to requests from the Ministry of Health, Labour and Welfare, the Cabinet Office, and the Fukushima Prefectural Government. This report outlines the background and efforts made by JART in this regard.

2. Background to the establishment of the Earthquake Disaster Countermeasure Headquarters and request for dispatching radiation surveyors

On the night of Friday, March 11, the Government of Japan declared a state of nuclear emergency. At TEPCO's Fukushima Daiichi Nuclear Power Station, enormous tsunamis inundated switchboards, disabled power supply, washed out oil tanks for emergency diesel generators, and disabled the circulation of water to cool fuel rods which was the outset of the accident. On the afternoon of Saturday, March 12, a hydrogen explosion occurred at Unit 1 of TEPCO's Fukushima Daiichi Nuclear Power Station. On the night of the same day, an evacuation directive was given out to residents within 20-km radius of Fukushima Daiichi. Under these circumstances, JART established the Earthquake Disaster Countermeasure Headquarters headed by JART President at its main office on Saturday, March 12 and discussed the issue of securing and dispatching radiation surveyors (radiological technologists) to cope with the radiological dispersal associated with the nuclear accident.

[Members of the Earthquake Disaster Countermeasure Headquarters]
Director-General: Yasuo Nakazawa (President)
Deputy Director-General: Kiyoshi Ogawa (Vice- President)
Deputy Director-General: Yasushi Ido (Vice- President)

Head Official: Yoshiaki Kitamura (Director)
Clerical officers: headquarters staff
Local Response Headquarters Director: Kenji Suzuki (Director, President of Fukushima Prefectural Association of Radiological Technologists)

[Roles of the Earthquake Disaster Countermeasure Headquarters]

(1) Coordination with the Local Response Headquarters
List of dispatched personnel, transportation means, and health checkup of dispatched personnel
(2) Coordination with surveyor applicants
Designation of leaders, forwarding of commissioning letters, and confirmation of contact information
(3) Surveyor activity report
Report to 47 Prefectural Governments
(4) Report on the procurement and management of GM counters, pocket dosimeters, etc.
(5) Survey report on damage in each prefecture of the Tohoku region
(6) Coordination with administrative agencies
(7) Consultation on radiation exposure
(8) Handling the public and mass media

At about 3:40 p.m. on Saturday, March 12, there was a request from TV Tokyo to make an impromptu appearance on TV. The Earthquake Disaster Countermeasure Headquarters discussed the matter at a meeting and decided to dispatch JART members Mr. Kunihiko Morozumi (Chairman of the Medical Exposure Safety Control Committee) and Mr. Hiroshi Watanabe (Acting Officer for Public Relations). We also asked for cooperation from all directors, 47 prefectural association president, officers, and radiation safety managers by email sent at 8:15 a.m. on Sunday, March 13.

[Request for cooperation sent to members throughout Japan]

Good morning, everybody.

(1) We would like to ask all the directors, 47 prefectural association president, and officers to collect information in each prefecture and promulgate correct knowledge on radiation according to our established policy when asked to offer consultation on radiation.
(2) According to media reports, about 160 residents have been exposed to radiation. Radiation surveys on residents may be conducted in the future. If there is a request to mobilize radiation safety managers and other personnel, we will cooperate as much as possible. If you have been mobilized on a prefectural basis, please report to the president of your prefectural association either before or after the mobilization. JART will communicate with each prefectural association president and pay for transportation, lodging, and measuring apparatus rentals as necessary.
(3) We ask the radiation safety managers throughout Japan to pay attention to media reports and cooperate in conducting emergency response to the extent possible for each person.
(4) As regards media relations, please be aware that Mr. Morozumi, Chairman of the Medical Exposure Safety Control Committee, will again appear on TV Tokyo today.

(5) Mr. Okada, Radiation safety managers Committee Chairman, and Mr. Ido, Vice President, are now preparing a nation-wide list of radiation safety managers who can be mobilized on a voluntary basis. I hope the association president throughout Japan will cooperate with requests from Mr. Okada.
(6) Please contact myself, Nakazawa (phone: 080-5916-8877) if you have any questions.

8:15 on Sunday, March 13, 2011
Yasuo Nakazawa, President of the Japan Association of Radiological Technologists

At around 10 a.m. on Sunday, March 13, the Atomic Energy Commission of the Cabinet Office and the Guidance of Medical Service Division of the Ministry of Health, Labour and Welfare asked us about the number of radiation surveyors we can dispatch and the number of GM counters we can lend to serve residents evacuated to shelters from the vicinity of TEPCO's Fukushima Daiichi Nuclear Power Station. Responding to this request, we held a second meeting of the Earthquake Disaster Countermeasure Headquarters to urgently solicit contributions from radiation surveyors and procure GM counters. Being also requested for cooperation by the Fukushima Disaster Countermeasure Headquarters (Coordination Headquarters for Emergency Exposure Medical Treatment), we consulted Mr. Suzuki, President of the Fukushima Prefectural Association of Radiological Technologists, and discussed plans to dispatch radiation surveyors to Fukushima Prefecture for a long time period. Responding to our solicitation, 12 radiological technologists from around the country gathered at the JART main office on Wednesday, March 16. After holding a kickoff ceremony, they headed for Fukushima Prefecture on a chartered bus registered as an emergency vehicle. The kickoff ceremony was reported by NHK TV on the same day. On Friday, March 18, JART received an office memo entitled "Request for cooperation with health centers, etc." from the Local Healthcare Office, General Affairs Division, Health Service Bureau, the Ministry of Health, Labour and Welfare. The memo mainly requested dispatching radiological technologists to prefectures or cities where health centers were located as well as lending GM counters. In response, JART asked the 47 prefectural associations of radiological technologists for cooperation. Based on an office memo from the Ministry of Health, Labour and Welfare, the Tokyo Metropolitan Government asked JART and Tokyo Association of Radiological Technologists for cooperation in radiation surveys on a voluntary basis. In response, the Tokyo Association of Radiological Technologists conducted radiation surveys from Thursday, March 24 to Tuesday, May 17 on evacuees who sheltered at Tokyo Big Sight and Ajinomoto Stadium. On Friday, April 8, there was a request from the Fukushima Prefectural Police Headquarters through the Ministry of Health, Labour and Welfare asking for radiation surveys on bodies before autopsy. We consulted Mr. Suzuki, who was in charge of local emergency response as President of the Fukushima Prefectural Association of Radiological Technologists, and conducted radiation surveys on bodies before autopsy during the period from Monday, April 11 to Wednesday, August 10. On Thursday, July 28, there was a request from the Ministry of Health, Labour and Welfare for dispatch of radiation control specialists to TEPCO's Fukushima Nuclear Power Station. JART has dispatched radiological technologists since Wednesday, August 31 up to now (as of Monday, February 20, 2012). On Sunday, February 5, 2012, there was a request from the Environmental Health Department of the Ministry of the Environment for a model project to support risk communication in Fukushima, and we operated an Internet consultation center on radiation exposure from Monday, February 20 to Saturday, March 24.

3. JART's policy on emergency exposure

In 1999, we started to qualify radiation safety managers in a new qualification system of radiological technologists. This system has the following objective:

(1) Nurture specialists to promote knowledge among the public on the safe use of radiation,
(2) Nurture specialists who lead and promote radiation hazards prevention and management techniques,
(3) Nurture specialists who conduct research projects for reducing medical exposure, and
(4) Nurture specialists who lead the development of emergency exposure preparedness.

Prior to the new qualification system, we have been providing professional training on clinical practices and conducting corresponding qualification tests by assuming medical care as the main field of activity. Meanwhile, one of the above-mentioned four objectives of the radiation safety managers qualification system is to nurture specialists who lead the development of emergency exposure preparedness. The lecture themes include "nuclear power related facilities" and "flow of air." Radioactive steam was released to the atmosphere due to the nuclear accident at TEPCO's Fukushima Daiichi Nuclear Power Station and residential areas were radioactively contaminated; thus, radiation safety managers, as radiation control specialists, are in charge of instructing radiation surveys to ease the anxiety of residents in such areas. As an organization to nurture radiation safety managers, we have been dispatching radiation surveyors as a must-do project of JART. Currently, about 2,755 radiological technologists are qualified and working nationwide as radiation safety managers.

4. Requests for supporting the health care of disaster victims

Since we started to dispatch radiological technologists to the Fukushima Disaster Countermeasure Headquarters on Wednesday, March 16, 2011, various problems have arisen. We summarized such problems, identified items necessary for delivering relief for disaster victims in Fukushima Prefecture and other areas, and submitted a petition to the Liaison Council for the Health Support of Disaster Victims. The specific items of the petition are as follows:

(1) Development of an efficient system of radiation survey on disaster victims

In the current system of radiation survey on disaster victims, dispatch may be requested separately from different organizations such as the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Health, Labour and Welfare, and the Federation of Electric Power Companies of Japan, and screening is conducted at permanent facilities in Fukushima Prefecture. The number of examination personnel including radiological technologists differs from day to day. For efficient deployment of personnel, we would like to ask the responsible persons to review and develop a chain of command and other systems. As many people have asked about radiation effects at permanent facilities and at least one radiological technologist must be stationed at each facility, we would like to ask the responsible persons to consolidate the chain of command and respond to medical institutions that are under the jurisdiction of the Ministry of Health, Labour and Welfare and the Ministry of Education, Culture, Sports, Science and Technology.

(2) Response to radiation exposure and health study

The valuable data of atomic bomb survivors in Japan are being used for determining international criteria on the health effect of radiation; 100 mSv in one incident of exposure has been used as the lower limit of detecting any effects.

Although the radiation exposure caused by the Fukushima nuclear accident was at low dose levels close to the detection limit, it is necessary to develop a system to conduct health studies on disaster victims and follow-up studies. A system for conducting studies in consideration of 10 to 20 years from now should be developed urgently.

(3) Response to harmful rumors associated with radiation exposure

In response to the fact that there are harmful rumors associated with radiation exposure, the relevant groups and associations should present a unified view on the effect of radiation exposure and explain the radiation effects on human health.

Harmful rumors are severely affecting not only the primary industries but also the export of industrial products. Some local governments even responded by expressing an attitude of avoidance of people living in the areas affected by the nuclear accident. While the response to the accident becomes prolonged, we urge people to address human rights issues as well.

(4) Development of radiation-related legislation and emergency response manual

The introduction of tentative regulation limits and emergency exposure limits after the occurrence of the accident have caused public distrust and a great disturbance in daily life. The safe operation and emergency response of nuclear facilities should be discussed in combination.

(5) Cross-ministerial development of regulations

At sites where people handle radiation, background radiation doses continue to be higher than doses in controlled areas, and consistency with the current laws cannot be achieved with respect to control criteria and other aspects. We earnestly urge administrative authorities to respond appropriately.

The petition, with the above five items, was discussed by the Liaison Council for the Health Support of Disaster Victims and summarized into three items as an official request from the Council; the request was submitted from Mr. Haranaka, Representative of the Council, to Mr. Tatsuo Hirano, Minister of State for Disaster Management of the Cabinet Office in charge of recovery from the Great East Japan Earthquake.

5. Response to mass media

At around 3 p.m. on Saturday, March 12, 2011, TV Tokyo asked JART to make an appearance on TV. We were requested to comment, as radiation specialists, on how we should address the anxiety of local residents about radiation exposure caused by the nuclear accident at TEPCO's Fukushima Daiichi Nuclear Power Station. We contacted JART members Mr. Kunihiko Morozumi (Chairman of the Medical Exposure Safety Control Committee) and Mr. Hiroshi Watanabe (Acting Officer for Public Relations) and dispatched them to TV Tokyo. They subsequently made appearance more than 30 times on Fuji Television Network, TV Asahi, FM J-WAVE, Fukushima Broadcasting, and other broadcast stations to provide explanations as radiation specialists.

6. Summary

As requested from the Ministry of Health, Labour and Welfare, the Atomic Energy Commission of the Cabinet Office, and the Fukushima Disaster Countermeasure Headquarters, JART called for voluntary cooperation from the 47 prefectural associations of radiological technologists. Many people volunteered from across the nation, and we managed to dispatch radiation surveyors to Fukushima Prefecture. The Fukushima Disaster Countermeasure Headquarters has acknowledged that our efforts have greatly helped reduce the anxiety of residents who have evacuated to shelters. Fukushima Prefectural Governor Yuhei Sato also acknowledged our activities. Responding to a request from the Ministry of Health, Labour and Welfare to dispatch radiation control specialists, JART has dispatched radiological technologists to TEPCO's Fukushima Nuclear Power Station. JART believes its mission to support the reconstruction efforts of people in the disaster-affected areas. Representing JART, I would like to express our sincere thanks to the volunteers who have responded to our solicitation, the family members who supported the volunteers, the officers of the 47 prefectural associations of radiological technologists who have been cooperative, and the facility directors who have approved the dispatch of their personnel.

Finally, I would like to extend my heartfelt sympathies to those who have been affected by the Great East Japan Earthquake and would like to pray for the souls of the deceased.

Activity introduction

Commitments made by the Fukushima Prefectural Association of Radiological Technologists

Fukushima Prefectural Association of Radiological Technologists
Kenji Suzuki, President

Introduction

The gigantic earthquake of magnitude 9 that occurred off the Sanriku coast in the Tohoku region on Friday, March 11, 2011 was the severest earthquake on record in Japan. In addition to the collapse of buildings, the tsunamis associated with the earthquake resulted in more than 20,000 people killed or missing. The next day on March 12, the tsunami disabled the cooling capability of Unit 1 of Fukushima Daiichi Nuclear Power Station, and the reactor building of the unit experienced a hydrogen explosion. As a result, radioactive iodine (I-121) and cesium (Cs-137) were released, and an evacuation directive was given out to residents within a 20-km radius of the power station. Shelters were set up throughout Fukushima Prefecture, and evacuees were subjected to emergency exposure screening.

Background to the dispatch of screening personnel

Eight to nine Fukushima Association members participate in the Fukushima Prefecture Nuclear Emergency Drills held annually by the Fukushima Prefectural Government to perform training on emergency exposure medical treatment according to the Fukushima Prefecture Emergency Exposure Medical Activity Manual. According to this manual, radiological technologists play a role in preparing the opening of first-aid stations, conducting body surface contamination monitoring with survey meters, and deciding the necessity of decontamination; all the work is conducted under the direction of the Nuclear Emergency Response Center of Fukushima Prefecture (off-site center in Okuma-machi). As the off-site center did not function during the Fukushima nuclear accident, things did not proceed as stipulated in the manual, and this caused confusion (Fig. 1). After the onset of the Fukushima nuclear accident, all communication means were lost due to the disaster. Therefore, the Fukushima Association received no request for dispatch, and persons in charge of nuclear emergency drills at the Fukushima Prefectural Government could not be reached by either home telephone or mobile phone. On Sunday, March 13, I decided to go to the Fukushima Medical University Hospital.
(It was fortunate that telephones were usable at the hospital.)

I confirmed that the Ministry of Education, Culture, Sports, Science and Technology had requested the Fukushima Medical University Hospital to dispatch emergency exposure screening personnel. After asking Mr. Kazumori Matsuo, Emergency Response Measures Examiner of the Nuclear Safety Commission, to let the Fukushima Prefectural Government request to the Fukushima Prefectural Association for dispatch of personnel, I went home and sent an email to the director of the Fukushima Association to request for dispatch. Immediately after this I went to the Fukushima Disaster Countermeasure Headquarters (Fukushima City) and received an oral request for dispatch from the person in charge for the Fukushima Prefecture. As a result, the dispatch of personnel for screening started on Monday, March 14. While I accepted the request for dispatch, I had to rely on telephone as an urgent means of communication. As I could not use my home telephone or mobile phone, I waited in line at a convenience store for a public telephone. As I made a phone call to one person to talk about the request for dispatch, I let the next person in line use the phone. I repeated this process several times to contact association members.

Development of screening system

On March 14, I asked Vice- President Yasuo Saito to organize the southern prefectural branch, and dispatched screening personnel to Koriyama City Gymnasium and Fukushima Prefecture Gender Equality Center (Nihonmatsu City). Meanwhile, Mr. Ikuo Watanabe, Deputy Director of the Aizu branch, informed us that there was a shortage of GM survey meters at the Fukushima Prefectural Aizu General Hospital, where he was conducting screening. As we possessed GM survey meters transferred from former President Toshihiko Katakura and slated for disposal, we promptly transported two of the GM survey meters to the Aizu General Hospital. The next day on Tuesday, March 15, the Fukushima Medical University Hospital and the Fukushima Preservative Service Association of Health also requested for the dispatch of personnel for screening, and the northern prefectural branch became ready to conduct screening as well.

As regards the screening system, the Division of Community Health Care of the Department of Health and Welfare of Fukushima Prefecture issued a detailed document describing specific actions to be taken; screening would be conducted according to this document (Fig. 2). In the initial stage of screening, many residents flocked to shelters and screening facilities and they ended up waiting for 4 to 6 hours to be examined. The screening conducted on March 15 at the University of Aizu lasted until 3 a.m., during which time personnel of the Aizu branch continuously conducted measurement. Meanwhile, additional shelters were set up at different locations and we began to circulate the shelters for screening. It became usual for one team to conduct screening at three shelters, and resulted in excess burden placed on the association members (see Table 1 and Fig. 3).

The Coordination Headquarters for Emergency Exposure Medical Treatment was set up to allow the association members to report each day's activities and plan the next day's screening and medical activities. This resulted in reviewing any problems within the day and feeding the results back to the next day's activities. I also participated in the meetings of the Coordination Headquarters (Fig. 4).

Screening work

The screening on Wednesday, March 16 dealt with residents and nuclear workers who were radioactively contaminated; at the facilities where the Fukushima Association dispatched personnel, 137 persons were found to have radiation levels of 13,000 to 100,000 cpm and 4 persons had radiation levels of 100,000 cpm or more.

The latter 4 persons were TEPCO workers from Fukushima Daiichi Nuclear Power Station. In one person, contamination was found in the hair and the lower body, and after decontamination, radiation levels were reduced to 20,000 cpm in the hair and 10,000 cpm in the lower body. Table 2 shows the number of personnel dispatched by the Fukushima Association and the number of people screened. During the period between the onset of the Fukushima Daiichi nuclear accident and Wednesday, May 25, the number of people screened at all the permanent screening facilities and shelters in Fukushima Prefecture reached 192,933; among them, 894 had radiation levels of from 13,000 to 100,000 cpm, and 102 had radiation levels of 100,000 cpm or higher. The examiners were initially wearing a Tyvek suit, cap, mask, and shoe covers during the screening work. From Sunday, March 20 onward, given that the number of people having radiation counts of 100,000 cpm or more had decreased, they stopped wearing Tyvek suits, which may look scary to residents. As the number of residents screened decreased, more people began to bring cars, vegetables, clothes, pets, soil, and industrial goods for screening. As the Coordination Headquarters for Emergency Exposure Medical Treatment could not handle every request, they introduced the following criteria for conducting screening.

(1) Cars left within 20-km radius are screened because their radiation counts are high.
(2) Pets accompanying the residents are screened.
(3) Vegetables cannot be evaluated properly because GM survey meters can measure only surfaces.
(4) Industrial goods are screened at the Fukushima Technology Centre.

Although the number of people screened has decreased, if evacuees are allowed a temporary visit to their homes within 20-km radius, we will need to screen these residents once again so that the number of people examined will increase. We must therefore discuss the screening system of the future.

Concluding remarks

The commitments of the Fukushima Prefectural Association of Radiological Technologists toward the future should focus on easing the anxiety of residents. Based on our specialist knowledge, we would like to actively address radiation-related questions raised by residents. Even within Fukushima Prefecture, people are sometimes not accepted for examination at a medical institution or not allowed to access shelters if they have not been screened. To address such and many other problems related to radiation, I keenly feel the need for enlightening residents on radiation.

There are harmful rumors that Fukushima Prefecture is entirely contaminated with radioactive material; as a result, some people refrain from accessing areas even where contamination is negligible and avoid purchasing products from Fukushima Prefecture. Transmission of correct information through the mass media is badly needed.

(From the interim report of June 11, 2011 prepared by the late Mr. Kenji Suzuki)

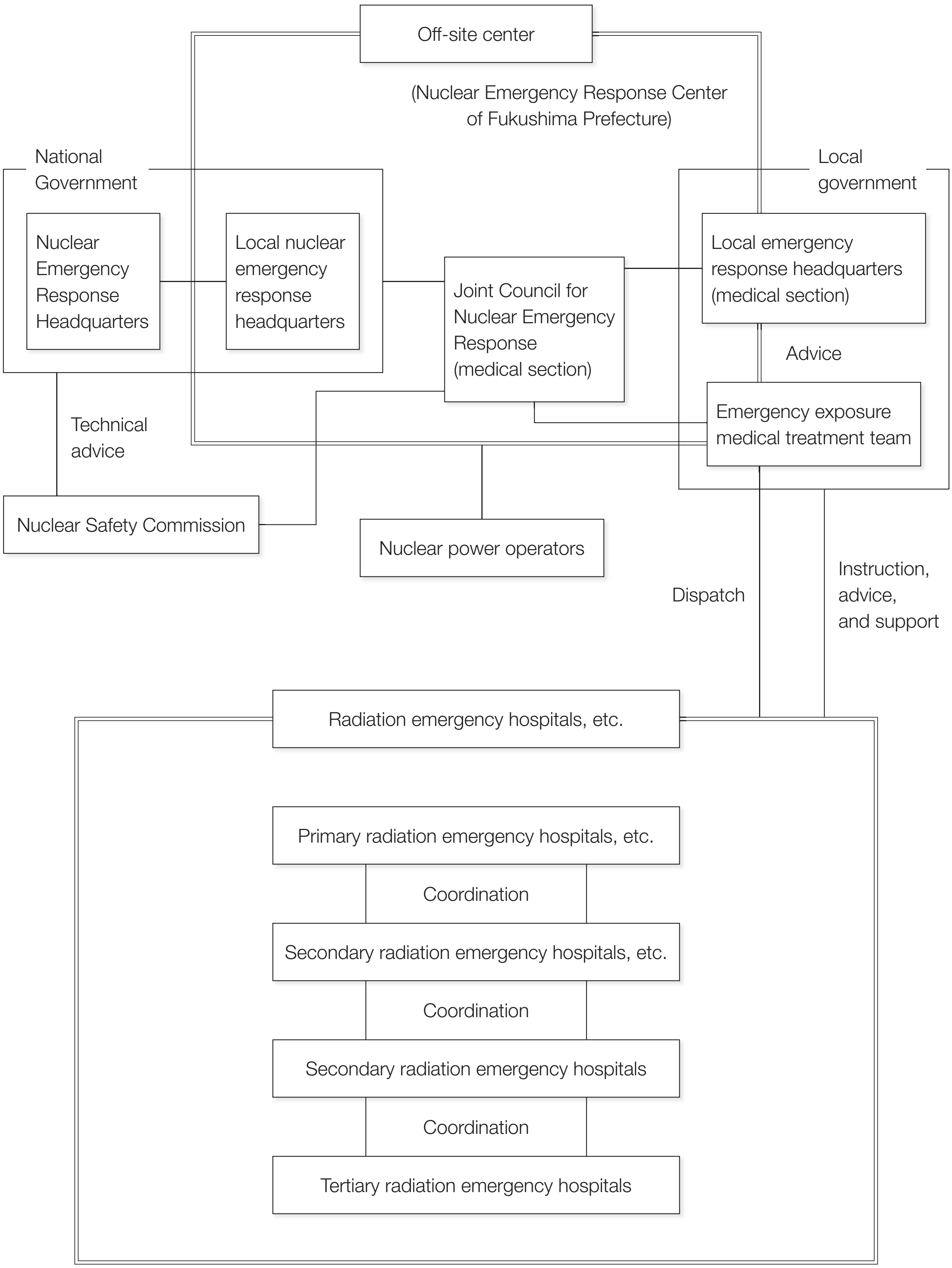


Fig. 1 Framework of emergency exposure medical treatment system
(Exc Fukushima Prefecture Emergency Exposure Medical Activity Manual)

Description of emergency exposure screening system

March 14, 2011
Division of Community Health Care, Department of Health and Welfare

The screening system on and after March 15 shall be as follows.

1. **Basic philosophy**

   Ensuring the safety and security of residents

2. **Specific actions**

   (1) Actions at each shelter
   Screening and decontamination are conducted by a team consisting of health center personnel and supporters.

   (2) Others (severely exposed patients)
   Once the Emergency Response Headquarters receives information, the client will be transported to Fukushima Medical University or the National Institute of Radiological Sciences, depending on the state of exposure.

3. **Change in screening levels**

   (1) Description of change
   The current screening level of 13,000 cpm for whole-body decontamination will be changed to 100,000 cpm.
   If radiation levels between 13,000 cpm and 100,000 cpm are detected, partial wiping for decontamination will be conducted.
   The change shall become effective as of March 14, 2011.

   (2) Reason for change
   The change was decided on March 13, 2011 based on the opinions of specialists on radiation exposure medical treatment dispatched by the Ministry of Education, Culture, Sports, Science and Technology to Fukushima Prefecture and researchers from the National Institute of Radiological Sciences, as well as the treatment adopted at Fukushima Medical University.

   (3) Explanation to residents
   The above actions will ensure that there will be no health effect on the residents.

4. **Treatment of wastewater in decontamination**

   On the basis of the opinions of the above-mentioned specialists, the wastewater generated will be treated as general drainage because its expected radiation levels will not affect the environment.

Fig. 2 Description of emergency exposure screening system

Fig. 3 Screening in practice

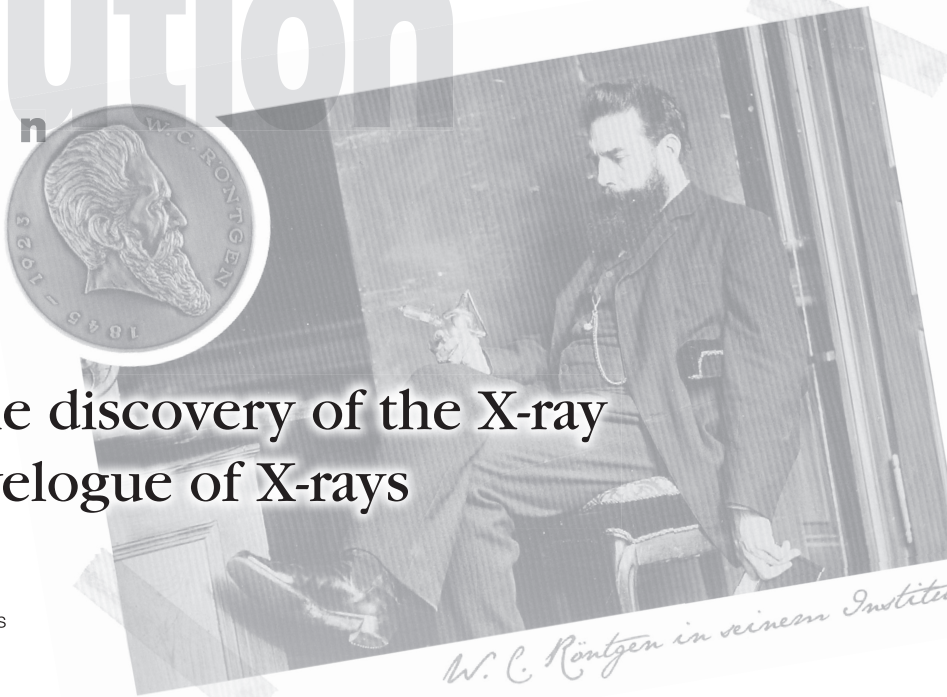
Fig. 4 Fukushima Prefectural Coordination Headquarters for Emergency Exposure Medical Treatment

Table 1 Permanent facilities and shelters where the Fukushima Prefectural Association of Radiological Technologists conducted screening (35 locations)

Aizu General Hospital	Minami-Aizu Hospital	Fukushima Gender Equality Centre	Koriyama City Gymnasium
University of Aizu	Fukushima Technical High School	Fukushima-Kita High School	Date City Gymnasium
Hashirazawa Community Hall	Fukushima High School	Yanagawa High School	Date City Fureai Center
Aizu Dome	Fukushima Terrsa	Paruse Iizaka	Fukushima-shi Daisan Junior High School
Kawamata-machi Iizaka Elementary School	Kawamata-machi Tsuruzawa Community Hall	Kawamata-machi Health Center	Big Palette Fukushima
Fukushima Meisei High School	Fukushima-shi Nankodai Elementary School	Hobara Daini Gymnasium	Yoshiida Learning Center
Shinryo Learning Center	Mochizuri Learning Center	Fukushima Commercial High School	Fukushima Training Center For Local Officers
Horai Elementary School	Horai Junior High School	Yamatsuri Local Community Development Center	Hanawa Community Hall
Kawamata High School	Shinobu Learning Center	Ichiban-kan	

Table 2 Number of personnel dispatched and the number of people screened by the Fukushima Prefectural Association of Radiological Technologists

Date	No. of locations	No. of personnel dispatched	No. of people screened	13,000 or more, less than 100,000 cpm (No. of people)	100,000 cpm or more (No. of people)
March 13	1	4	27	0	0
March 14	4	14	1,517	0	0
March 15	6	20	4,711	41	0
March 16	5	17	3,535	137	4
March 17	9	22	3,314	22	0
March 18	7	27	2,620	40	1
March 19	9	28	2,196	25	1
March 20	5	22	1,519	7	0
March 21	4	22	1,124	2	0
March 22	4	18	1,584	33	0
March 23	3	9	718	3	0
March 24	3	7	765	2	0
March 25	3	8	767	1	0
March 26	2	4	510	2	0
March 27	2	5	512	0	0
March 28	2	3	425	0	0
March 29	2	3	404	4	0
March 30	2	3	431	0	0
March 31	2	3	465	3	0
April 1	1	2	131	0	0
April 2	1	2	108	0	0
April 3	1	2	130	0	0
April 4	1	2	84	0	0
April 5	1	2	77	0	0
April 6	1	2	54	0	0
April 7	1	2	74	0	0
April 8	1	2	63	0	0
April 9	1	2	82	0	0
April 10	1	2	148	0	0
April 11	1	2	70	0	0
April 12	1	2	101	0	0
April 13	1	2	84	0	0
April 14	1	2	44	0	0
April 15	1	2	78	0	0
April 16	1	2	122	0	0
April 17	1	2	110	0	0
Total	92	273	28,704	322	6



120 years since the discovery of the X-ray - The German Travelogue of X-rays

Kunihiko Morozumi
Specialist
The Japan Association of Radiological Technologists

Introduction

This year is the 120th anniversary since the discovery of the X-ray by Wilhelm Conrad Röntgen (1845 - 1923) in November 8th, 1895. In August 2014, I visited Germany and visited places that had connection to Röntgen and the X-ray. I then wrote a German travelogue different from the usual 'Romantic Road' theme. It is my hope that this travelogue will be helpful to people planning a trip to Germany in the times ahead. Further, the names of places, transportation situation, and the Euro (€) within this document are all as it was in August 2014.

A trip by plane to Germany from Japan takes 11 hr and 30 min. This time, since I was planning to visit Röntgen's grave first, I went from Haneda airport to Frankfurt.

Since I took the D-shuttle Dosimeter (Chiyoda Technol Corporation) that can determine radiation dose in time units, I indicate to you the in-flight dosage rate (Diagram 1). When the altitude surpassed 10,000m, the value that was 0.05 μSv/h on the ground reached 1.5 μSv/h.

Frankfurt is situated in the topographical center of Germany and is the railroad heartland (Diagram 2). Considering my subsequent travels, I stayed at a hotel near Frankfurt (Main) Hauptbahnhof (central station) and made that my starting point. Being a giant metropolis, Frankfurt is also convenient for shopping, and there are also many sightseeing spots. Buying the Frankfurt Map (€0.50) at the Tourist Information makes things handy.

Giessen

The railroad is developed in Germany like it is in Japan. That dogs and bicycles confidently occupy spaces on trains dedicated to them is

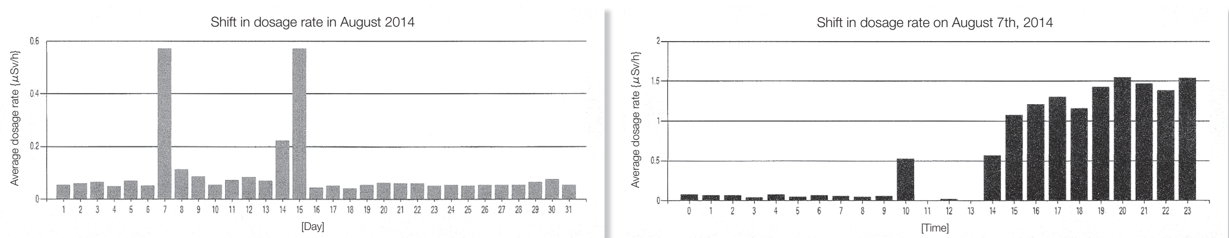


Diagram 1: Measured results of the personal exposure dosimeter (D-shuttle)
The reason why a high dosage rate is shown on August 7th and August 15th in the top diagram is due to the altitude of 11,000 m during the flight. The peak on August 7th at 10 am in the lower diagram is due to passing through the baggage inspection section. The average dosage rate during the flight following boarding LH717 at 2:15 pm was at maximum 1.5μSv/h.

an enviable scene. If you buy a German Rail Pass and a reserved seat on a train along with your plane ticket from your travel agent before leaving Japan, it will be handy when verifying the train number and the track that the train will be departing from is concerned. It depends on the season, but it was 30,000 yen including service fees for 2nd class seats for 3 days. Further, 3 days means any 3 days within a month and continuous use is unnecessary. All you need to do is get a confirmation for the day you ride the train.

The timetable is not by train line, such as the Tokaido Line or the Joetsu Line; all the trains departing from the station are arranged according to the time of departure. Therefore, it would be a good idea to check the number of the train you will be taking the next day along with the track number.

Since there is no ticket gate at German train stations, you just get on the train. However, the conductor will come to inspect your ticket in the train. This is when you show your German Rail Pass and get the date marked on your ticket.

Giessen is approximately 40 minutes from Frankfurt and is where Röntgen spent his time as a professor of physics at the University of Giessen from 1879 to 1888. The school building where he taught still remains (Photo 1).

After getting of at Giessen station, and you plan to go by taxi, tell the taxi driver, Alter Friedhof (old cemetery). My German was poor and so the taxi took a detour via Neuer Friedhof (new cemetery). On the gate is a bulletin board by the University of Giessen who manages the gravestones. There is an information map (pamphlet) for this cemetery because there are many other famous people buried here. Thus, here and there within the cemetery, are direction boards leading to Röntgen's grave. Follow these direction boards for about 200 m, and you will arrive at Röntgen's grave.

The grave was immaculately clean and decorated with beautiful flowers. Both Wilhelm Conrad Röntgen and his wife Berta as well as his parents are buried here (Photo 2). If you look at the gravestone, you will see that Bertha died at the age of 89 on October 31st, 1919. Then, 3 years following her death, Wilhelm Conrad died on February 10th, 1923, just a little over a month before his 78th birthday. Although Wilhelm Conrad Röntgen is spelled with a C in all literatures, the gravestone is inscribed with his name spelled as KONRAD.

On the way to Giessen station from Alter Friedhof (old cemetery), when you turn the

Photo 1: Justus Liebig University Giessen (University of Giessen)

The Justus Liebig University Giessen (University of Giessen) was where Röntgen spent his years from 1879 – 1888 as a professor of physics.

Photo 2: Professor Röntgen's gravestone

Röntgen's gravestone was very tranquil at the Alter Friedhof (old cemetery)

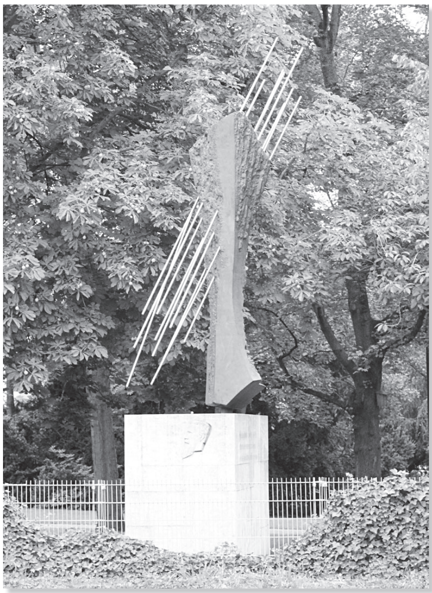


Photo 3: Röntgen’s monument
A memorable monument shaped like a new ray of light going through a billet in an angle. There is a relief of Röntgen on the pedestal.

Photo 4: Deutsches Röntgen-Museum

Photo 5: Exhibits in the museum (Röntgen lost in thought)

corner at Ludwigs Patz and arrive at Berliner Platzt, you will see a monument shaped like a ray of light going through a billet in an angle (Photo 3) on the left of the park from the Stadttheater theater. The following inscription can be found on the pedestal with Röntgen’s relief: “Wilhelm Conrad Röntgen (1845 - 1923) was a full professor of physics at the University of Giessen from 1879 - 1888.”

Remscheid-Lennep

Lennep, where Röntgen was born, was an old town along the commercial route heading toward the Baltic Sea. It was annexed by the city of Remscheid in 1929 and hence is now Remscheid-Lennep.

You get off at the branch line of Wuppertal via Koln from Frankfurt. Then, from there, you head toward Remscheid-Lennep on the bus. You get off at the front of Lennep’s old station building, but due to the fall in users of trains, the station building was surrounded by an iron fence and looked forlorn and miserable.

Turn your back on the station building and walk along the ring-shaped street. On the left side you will see a sign saying, Deutsches Röntgen-Museum. Continue to walk while trying to remember the location of the street sign for your return treck. The Deutsches Röntgen-Museum (Photo 4) is closed on Mondays, so if you want to go you should verify the days and times the museum is open in advance.

When you walk in, on the right is the old Haus 1. Here, you will find things related to Röntgen’s life, furniture that he used, etc. on exhibit. In Haus 2 and Haus 3, you will find things related to X-rays such as the basics to the applied, as well as the earliest up to the latest X-rays orderly exhibited (Photo 5).

The history of the development of X-ray

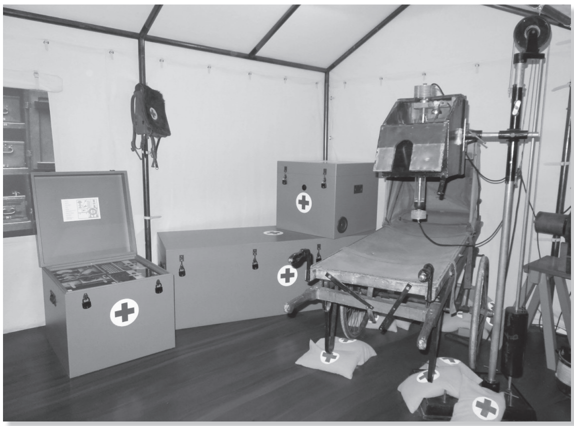


Photo 6: Exhibits in the Röntgen-Museum
Devices that were active during the First World War

Photo 7: Röntgen's birthplace
It was being worked on (under construction) in the summer of 2014.

equipment such as the various X-ray tubes, the vacuum pumps, induction coils, generators, and accessories are exhibited (Photo 6).

If you walk out of the museum and turn left, and then turn right at the fork in the road up ahead and keep walking for about 100 m, you will find Röntgen's birthplace (Photo 7). Since the house was hard to differentiate from the other houses, I asked a local person which one it was and showing a photo I brought from Japan. It was the house under construction. I wanted to verify the nameplate of Röntgen's birthplace, but I was unable to as it was hidden by construction work fence. However, something like the following is apparently written in German.[1)]

Photo 8: Physics Laboratory, University of Würzburg

I wasn't able to see it this time, but I would like to make it my reason for visiting the place again.

[This is the house where Wilhelm Conrad Röntgen, the person who discovered the 'ray' named after him was born on March 27th 1845. In 1896, he was conferred the title of honorary townsperson from the town that was his hometown.]

Würzburg

Würzburg is 70 min from Frankfurt and is a beautiful sightseeing spot on the northern starting point of the 'Romantic Road.' Röntgen married Bertha while working at the University of Würzburg as an assistant from 1870 to 1872. Subsequently, while working as a professor of physics (1888 - 1900), he discovered the X-ray.

If you turn right on Röntgen Ring from Würzburg Hauptbahnhof (Hbf or Würzburg Central Station), there is a monument to the discovery of the X-ray between the University of Würzburg buildings. If you proceed further, there is a light green building (Photo 8) which is the University of Würzburg's physics laboratory, and in the left corner of the room on the 2nd floor, the X-ray was discovered during research on the cathode ray. On the wall surface is written, “In this room, Wilhelm Conrad Röntgen discovered the ray named after him in 1895” (Photo 9). On the 1st and 2nd floors are the physics laboratory, the experimental laboratory, and the lecture room. The 3rd floor is the division where the Röntgens resided and was also a place where Röntgen was able to lead the most enjoyable fulfilling days of his life.[2)]

After passing that and moving on for another 10 m, there is the entrance to the Röntgen Memorial. When you open the heavy door on the 2nd floor, you will enter a hall. Proceeding down the left corridor will lead you to the room where Röntgen actually discovered the X-ray. You can see the room through a transparent plastic door (Photo 10).

Here, the device used by Röntgen to discover the X-ray is exactly the same as it was at that time. However, the Ruhmkorff coil is a replica and the real thing is exhibited at Munich’s Deutsches Museum. Devices and equipment used at the laboratory during those times are exhibited in the adjoining room and these historical exhibits are worth seeing.

You will be able to fully enjoy the old cityscape of Germany if you tour the famous residences, the Marienberg Fortress, and more after visiting the physics laboratory.

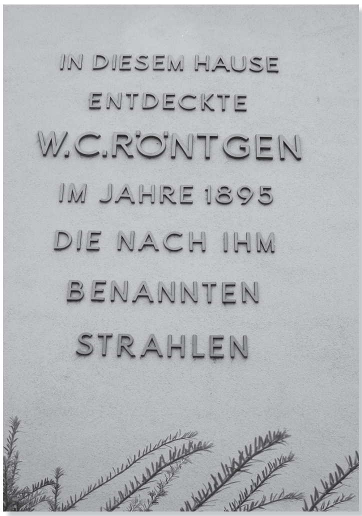


Photo 9: The name plaque on the wall of the Physics Laboratory, University of Würzburg

Munich

In Munich, I looked for the building where Röntgen spent his last days. German streets are indicated with historical figures, and there, at 11 Maria Theresia street, was a brilliant modern 2-story residential building built of bright brown bricks (Photo 11).

The following was written on the wall plaque (Photo 12) displayed at the house where Röntgen passed away.[1)]

“Wilhelm Conrad Röntgen, the full professor of Experimental Physics at the University of Munich (tenure years 1900 - 1923) and also

Photo 10: The laboratory where Röntgen discovered the X-ray

Photo 11: The building where Professor Röntgen passed away

Photo 12: The plaque describing Professor Röntgen's passing

Photo 13: The X-ray-related item exhibits in the Deutsches Museum.

the person who discovered the 'ray' named after him lived in this house from 1919 to 1923. He died on February 10th 1923."

After that I went to Isartor from München Hauptbahnhofto and headed for the Deutsches Museum. Here, is one of the greatest Science and Technology Museums in the world that was opened in 1925 by Oskar von Miller. If you were to take your time to look around, one day is almost not enough to see all the exhibits. In one corner of the physics exhibit room (1st floor: 2nd floor) is exhibited a picture of Röntgen's experimental laboratory at the University of Würzburg, the Ruhmkorff coil (the real thing) that he used in his experiments, and pictures of the early times (Photo 13).

Here, there are no personal Röntgen exhibits like those at the Deutsches Röntgen-Museum, but basic matters are thoroughly explained and are definitely worth seeing. If you have one hour, you will be able to see the X-ray related exhibits. And after that, if you walk around and look at the ship, airplane, locomotive, and automobile exhibits, you will spend the entire day there. It would also be fun if you could visit Munich during Oktoberfest (beer festival).

Conclusion

There are a myriad of purposes for travelling to Germany: Soccer, beer, the 'fairy tale road,' the 'romantic road,' the Rhine River sightseeing, and touring the ancient castles. It would be a blessing to me if this can be used as a guide for you on your trip to Germany to visit the footsteps of Röntgen, the one who cleared the way for radiology.

Reference

1) Michio Yamazaki: The Life of Wilhelm Conrad Röntgen, discoverer of the X-ray, Koukodo, 1989
2) Michio Yamazaki: Wilhelm Conrad Röntgen, the Solitary Scientist, Iryokagakusha, 1995
3) Taiji Aoyagi: The person who opened the door to modern science: Wilhelm Conrad Röntgen and the Discovery of the X-ray, Kouseisha Kouseisha, 2000
4) Tomizo Kato: Illustration: The medical history of radiation, Kodansha, 1994

Arts and Sciences

Clinical usefulness of the serial ADC analysis in follow-up evaluation after Gamma Knife surgery for metastatic brain tumors

Kohei Kawasaki[1)] Osamu Nagano[2)] Kyoko Aoyagi[2)] Takahiro Kageyama[1)]

1) Department of Radiology, Chiba Cardiovascular Center
2) Gamma Knife House, Department of Neurosurgery, Chiba Cardiovascular Center

Key words: metastatic brain tumor, Gamma Knife surgery, apparent diffusion coefficient, radiation necrosis, tumor recurrence

【Abstract】
Magnetic resonance imaging (MRI) is usually carried out in follow-up evaluation after Gamma Knife surgery (GKS) for metastatic brain tumors. The purpose of this study is to assess the utility of serial measurements of the apparent diffusion coefficient (ADC) values in differentiating radiation effects from tumor recurrence. We enrolled 57 metastatic brain tumors (>10mm in maximum diameter) from 51 patients treated with GKS in our institution from February 2011 to September 2012. Diffusion weighted imaging was added to conventional MRI, and the ADC values were measured every three months at least. The ADC index was defined as the ratio of normalized minimum ADC value in the latest observation to that of the former observation and was used for chronological evaluation. During follow-up, four lesions were diagnosed as tumor recurrence. In these lesions, the ADC indices were lower than 1.00 when the tumors were diagnosed as recurrences. In the cases of good outcome, the ADC indices were higher than 1.00. Based on these results, a reduction of the ADC indices between two consecutive exams strongly suggests tumor recurrence. The serial ADC analysis can be one of the reasonable diagnostic tools to distinguish tumor recurrence from radiation necrosis in follow-up imaging after GKS.

1 Introduction

In follow-up imaging after Gamma Knife surgery (GKS) for metastatic brain tumors, several examinations are performed in combination to discriminate between tumor recurrence and radiation necrosis [1-4)]. Magnetic resonance imaging (MRI) is generally used for a morphological diagnosis. On the other hand, Single-Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) provide functional imagings and these are useful for differentiation of tumor recurrences and adverse radiation effects [2-4)]. However, radioisotope examinations such as SPECT and PET are not available at all of the facilities and cost much more than MRI. Hence, in order to diagnose tumor regrowth rationally, we utilized the Apparent Diffusion Coefficient (ADC) values, which were easily obtained by adding Diffusion Weighted Imaging (DWI) to conventional MRI protocol. Since MRI is simple, widely available and low cost tool compared to SPECT and PET, it can be taken as consecutive examination. Goldman M, et al. [5)] reported a useful prognostic measure of tumor response using the ADC values at the initial post-GKS follow-up. Their study, however, has a limitation that patients often underwent follow-up at off-site locations, and they could not standardize follow-up imaging protocols. In the present study, we defined a quantitative index of the ADC value (ADC index) for follow-up evaluation after GKS and analyzed the ADC index chronologically.

2 Materials and methods

This study was approved by institutional review board (IRB) of our hospital (IRB No.

363). We took care not to infringe on the patients' right to privacy by making the data anonymous.

2-1 Patient characteristics

From February 2011 to September 2012, 57 metastatic brain tumors (>10mm in maximum diameter) from 51 patients were enrolled in the present study. Patients who underwent prior radiosurgery and craniotomy were excluded. We also excluded patients with MRI evidence of hemorrhagic metastases at pre-treatment. Patient characteristics, tumor location, and primary cancer are presented in Table. All patients were performed GKS using the Leksel Model C Gamma Knife (Elekta Instruments AB, Stockholm, Sweden), and underwent consecutive MRI examinations in our institution.

Table Patient characteristics

Characteristic	Value
Total no. of patients	51
Men/women	30/21
Age (years), median (range)	66 (33-89)
Tumor location	
Frontal	18
Temporal	6
Occipital	5
Parietal	10
Basal ganglia	3
Brain stem	5
Cerebellum	10
Primary cancer	
Lung	34
Breast	6
Rectum	3
Kidney	3
Esophagus	2
Others	3

2-2 Magnetic resonance imaging

We employed 1.5-tesla MRI system (Achieva; Philips Healthcare, Best, The Netherlands) with 8-channel head coil. Conventional MRI consisted of axial T2 weighted turbo spin echo, contrast-enhanced T1 weighed fast field echo, and coronal contrast-enhanced T1 weighted spin echo sequences.

DWI was performed in the axial plain using a single-shot spin echo, echo planar imaging sequence with the following parameters: repetition time = 1886msec, echo time = 68msec, matrix = 112 × 86, field of view = 230mm, slice thickness = 6mm, slice gap = 1.5mm, number of signals averaged = 1, b value = 0 and 1000sec/mm2, acquisition time = 23sec. The ADC map was computed from the raw DWI data by use of the standard scanner console software. In addition, contrast enhanced T1 weighted spin echo image which was same as DWI for a field of view, a slice thickness and a slice gap was acquired, in order to set the region of interest (ROI) on the ADC map (see section 2-3).

2-3 Serial ADC measurements

The ADC values of metastatic brain tumors were measured every three months at least. A radiological technologist (K. K) and a neurosurgeon (O. N) set the ROI for each lesion by consensus as follows. First, we compared contrast-enhanced T1 weighted image to T2 weighted image carefully, and drew the ROI in the tumor lesion on the contrast-enhanced T1 weighted image which was same as DWI for a field of view, a slice thickness and a slice gap. Next, the T1 weighted image with the ROI and the ADC map were displayed side by side, and the ROI was copied and pasted on the ADC map. The form of the ROI was modified as necessary. The minimum ADC values for each ROI were measured. The ADC value of tumor was normalized to normal-appearing white matter. The ADC index was determined as the ratio of normalized minimum ADC value in the latest observation to that of the former observation. In the present study, The ADC indices were calculated serially during the follow-up. The ADC index was regarded as 1.3 when drawing the ROI was difficult due to tumor shrinkage (i.e., successful therapeutic response) with reference to the previous report [5)].

Lesions were diagnosed as tumor recurrence and closely observed when the following clinical signs were observed: an increase in tumor size in contrast-enhanced T1 weighted image, a hot spot in Thallium-201 chloride SPECT [2], and deterioration in neurological symptoms.

3 Results

3-1 Serial ADC measurements

Change of the ADC index in serial follow-up after GKS are shown in **Fig. 1**. Among 57 lesions, four cases were diagnosed as tumor recurrence and another two cases needed intensive follow-up. In the lesions that showed good response after treatment, the ADC indices were higher than 1.00. In contrast, the ADC indices were lower than 1.00 when tumor recurrence were suspected.

3-2 Case presentation

Case 1. This 72-year-old man had 37mm single brain metastasis in the left parietal lobe from lung cancer (**Fig. 2 a**). The lesion was treated by three-session GKS with 10Gy in the peripheral dose on each fraction [6]. The ADC index in this case showed typical decrease at the time of recurrence (**Fig. 2 g**). At the 2nd follow-up, the lesion was well-controlled and the ADC index increased (**Fig. 2 b, g**). At the 3rd imaging, the reduction in the ADC index associated with tumor regrowth was observed (**Fig.2 c, g**). The lesion was diagnosed as a recurrence and retreatment was performed. The ADC indices were high during next two examinations (**Fig.2 d, e, g**), but dropped down again at the 6th follow-up and then the second retreatment was needed (**Fig. 2 f, g**).

Case 2. This 76-year-old man had 22mm single brain metastasis in the right parietal lobe from lung cancer (**Fig. 3 a**). The lesion was irradiated with 22Gy in peripheral dose. At the 2nd follow-up, the ADC index decreased although there was no tumor regrowth (**Fig. 3 b, f**). As shown in MR images, the intratumoral bleeding occurred after irradiation in this case (**Fig. 3 b**). The ADC indices at the 3rd and 4th follow-up were higher than or equal to 1.00 (**Fig. 3 c, d, f**), but decreased again to 0.73 at the 5th follow-up (**Fig. 3 e, f**). The lesion was

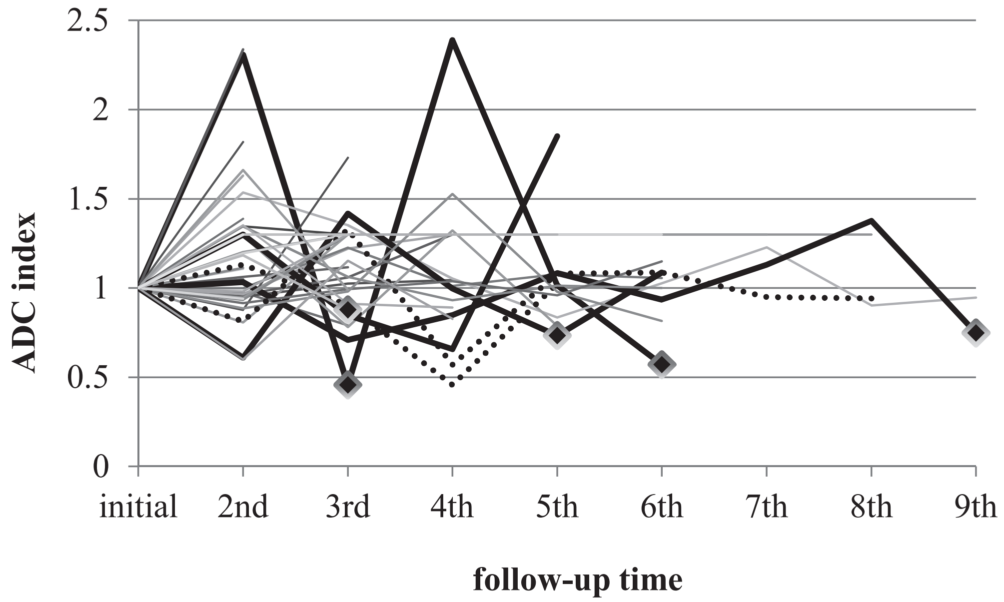


Fig. 1 Change of the ADC index in serial follow-up

Bold lines indicate retreatment cases, and *dashed lines* indicate intensive follow-up cases. The ADC indices were higher than 1.00 in the cases that followed good response after treatment, whereas the ADC indices were lower than 1.00 when we diagnosed tumor recurrence (*rhombuses*).

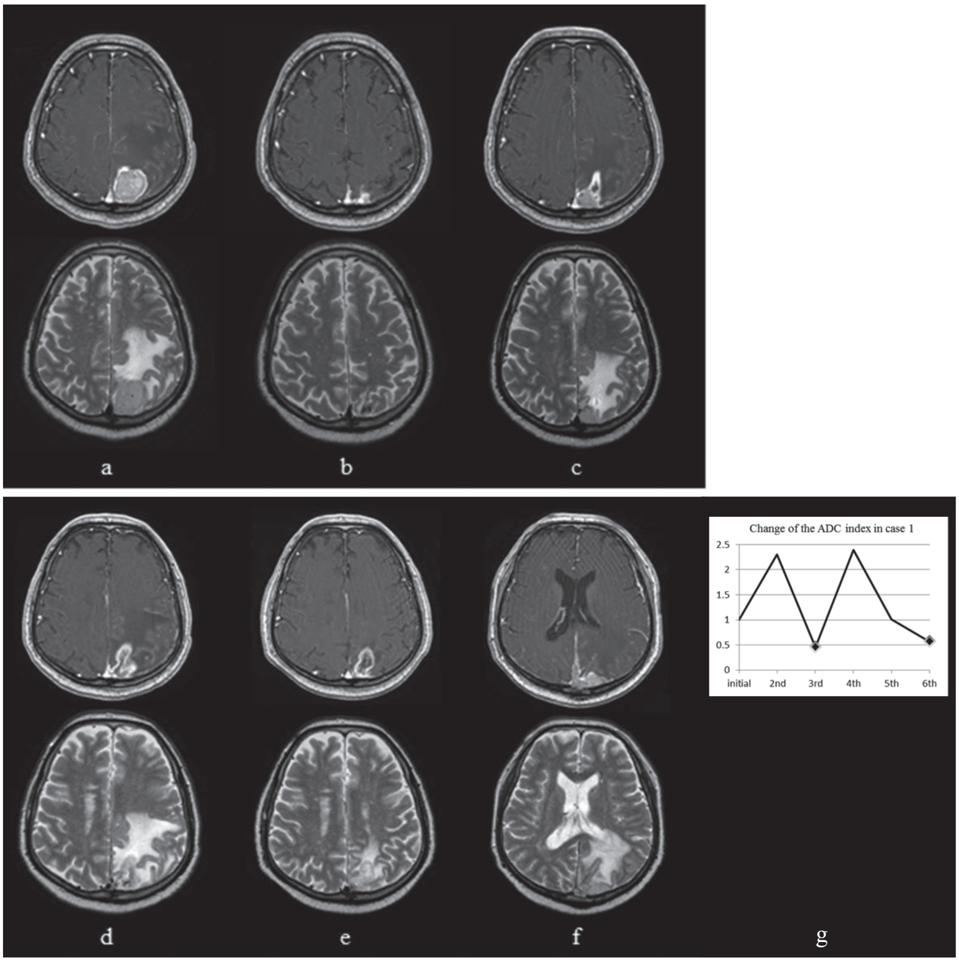


Fig. 2 Serial MRIs obtained in Case 1

a) Pre-GKS, these images demonstrate a metastatic brain tumor in the left parietal lobe.
b) 2nd follow-up, the lesion showed marked shrinkage and the peritumoral edema subsided. The ADC index was 2.31.
c) 3rd follow-up, the ADC index decreased to 0.46. The lesion was diagnosed as a recurrence and retreatment was performed.
d), e) 4th and 5th follow-up respectively, the ADC remained high value (2.39 at 4th and 1.02 at 5th follow-up).
f) 6th follow-up, the ADC index dropped down again (0.29), and the second retreatment was needed.
g) Temporal change in ADC index, the ADC indices decreased to lower than 1.00 when retreatments were needed (*rhombuses*).

diagnosed as recurrence and retreated.

4 Discussion

To differentiate tumor recurrence from adverse radiation effects after radiosurgery is significant clinical issue on patient practical management. Although functional imaging methods including SPECT and PET are useful, these are not routinely available. Meanwhile, the utility of the ADC value in differentiating between these conditions has been reported[5, 7]. Since the ADC value is easily measured by adding DWI to conventional MRI protocol, such an image analysis method is suitable for repeated examinations if it would provide reliable information. We defined the ADC index and observed its temporal change. The present study aims to assess the efficacy and limitations of the ADC index analysis after GKS for metastatic brain tumors.

The ADC value reflects the mobility of water in the tumor. The extracellular water increases in association with a decrease in the cellulari-

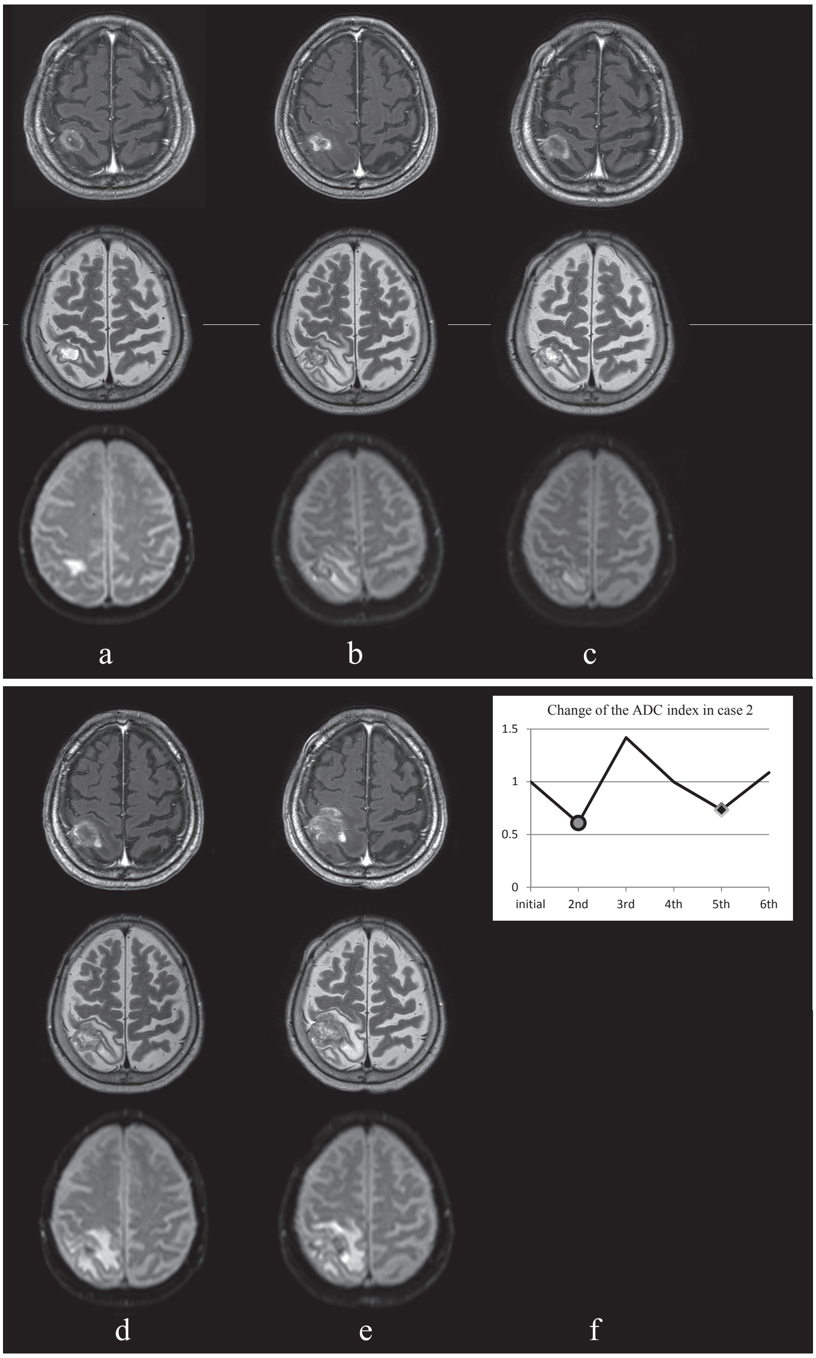


Fig. 3 Serial MRIs obtained in Case 2

a) Pre-GKS, these images depict brain metastasis in the right parietal lobe.
b) 2nd follow-up, the tumor size reduction was observed, but the ADC index decreased to 0.61. The intratumoral bleeding occurred after irradiation.
c) 3rd follow-up, the ADC index increased to 1.42.
d) 4th follow-up, the ADC index was 1.00.
e) 5th follow-up, the tumor increased in size, and the ADC index decreased to 0.73. The lesion was diagnosed as recurrence and treated again.
f) Temporal change in ADC index, note that the ADC index went down to lower than 1.00 when intratumoral bleeding was observed (*circle*). *Rhombus* represents recurrence.

ty of tumor tissue, as tumor cells undergo necrosis or apoptosis due to irradiation [5, 7]. Because the ADC value is inversely correlated with cellularity, necrotic tissues and cystic lesions have high values [8]. In contrast, solid tumors and tumor regrowth indicate low ADC values. The data obtained in the present study were consistent with the finding of previous studies. The ADC indices were higher than 1.00 in the cases of good outcome and were lower than 1.00 when tumor recurrence were strongly suspected, suggesting that the reduction of the ADC value between two consecutive exams meant recurrence.

Our retreatment case 1 presented the typical change of the ADC index in serial follow-up evaluation after GKS. In the lesion consisting of a solid portion and a component of radiation necrosis, ADC index analysis is particularly effective method for accurate diagnosis of recurrent tumor. Our retreatment case 2 demonstrated that the ADC index decreased in spite of tumor shrinkage. Follow-up MR images revealed the intratumoral bleeding after GKS in this case. In no signal region on T2 weighted echo planar imaging, the signal is not detected on DWI with motion proving gradient owing to the susceptibility effect derived from hemoglobin in the hemorrhagic portion. Thus, the reduction of the ADC index might not suggest recurrence in the lesion with the intratumoral bleeding.

Huang CF, et al. [7] showed measurement of the ADC value could be used to evaluate the tumor response to GKS. This study, however, was limited to patients with solid or predominantly solid metastases, in contrast to the present study which include cystic, necrotic, and heterogeneous lesion as well. Thus, the ADC index can be applied to miscellaneous metastases in follow-up evaluation after GKS.

Kano et al. [1] reported a 'T1/T2 mismatch' method to differentiate tumor progression from radiation effects by use of T2 weighted image and contrast-enhanced T1 weighted image. Besides, Cha J, et al. [9] found that the presence of three-layer pattern of ADC was highly specific for radiation necrosis. The combined analysis of the ADC pattern with regional cerebral blood flow may have added value in the correct differentiation. The methods predicted a radiation induced effect with high sensitivity and specificity. By adding serial ADC follow-up to their methods, diagnostic accuracy may be further improved.

In Japan, The Ministry of Health, Labour and Welfare requires that radiological technologists should assist physicians in radiographic image interpretation. In this sense, the ADC index is suitable for an objective evaluation as it has a quantitative value. Therefore, serial ADC measurements could have potential to be an effective tool when radiological technologists advise physicians on diagnostic imaging to distinguish recurrent tumor from radiation necrosis.

The ADC index analysis has several limitations. First, tumor recurrence was defined only by MRI, Thallium-201 chloride SPECT, and deterioration in neurological symptoms without histologic confirmation. Second, the steroid therapy may slightly affect the ADC value [6]. We generally use steroid medications for patients with brain metastatic tumors to alleviate neurological symptoms by decreasing the peritumoral edema. It is necessary to take into account for the phenomenon in serial ADC measurements. Finally, the significant reduction of the ADC value is observed in the intratumoral bleeding after GKS, such as in our case 2. Even though the ADC index may be lower than 1.00 in this situation, it would be easy to differentiate hemorrhagic lesion from tumor recurrence when serially evaluated in conjunction with conventional MRI. Although the ADC index analysis has still limitations, it might be valuable tool supporting diagnosis of recurrence in the post GKS follow-up.

5 Conclusions

We report the useful method using DWI in follow-up imaging after GKS. The ADC indices were higher than 1.00 in the cases that followed good outcome after treatment. For the recurrent cases, the ADC indices were lower than 1.00. Serial analysis of the ADC index is a reasonable method to distinguish tumor recurrence from radiation necrosis in follow-up evaluation for metastatic brain tumors.

We presented this study in part at the 28th Japan Conference on Radiological Technologists held in Nagoya, Japan in September 2012, and received a letter of recommendation of the paper submission.

Conflict of interest
None.

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Measurement of anxiety regarding mammography for new radiological technologists –Effectiveness of prescreening training–

Ai Watanabe[1)] Kyoichi Kato[2)] Mitsuyoshi Yasuda[3)] Mayumi Aso[3)]
Hisaya Sato[4)] Azumi Isaka[5)] Toshiyuki Takahashi[4)] Yasuo Nakazawa[2)]

1) Department of Radiology, Showa University Fujigaoka Hospital. (present: Department of Radiology, Nihon Koukan Hospital)
2) Showa University Graduate school Professor.
3) Department of Radiology, Showa University Fujigaoka Hospital.
4) Showa University Graduate school Instructor.
5) Department of Radiology, Showa University Toyosu Hospital.

Key words: Mammography, Prescreening, New radiological technologist rookie, Training, Anxiety

【Abstract】
Since routine mammography has been in the environment performed alone by one radiological technologist (RT) in many medical institutes, there is much anxiety in respect of diagnostic accuracy. In this study, we evaluated whether medical anxiety would relieve or not through extracting uneasy elements and forming measure to them.

"Shortage of knowledge required in order to diagnose mammography" became clear as an uneasy element by our evaluations.

Especially, since it turned out that distinction of mass lesions is difficult, we created the text for exclusive use as solution and trained RT (2people) by using this.

In results, after this training ability for diagnosing mammography improved 25% higher than that before training, and up to 60% of anxiety complex decreased.

From above our evaluation, "creation of the exclusive text by experienced RT and instruction training by using this text" were quite effective for uneasy measures in mammography study. And through these training the necessary knowledge for diagnosing mammography could be obtained and anxiety complex could be relived.

Introduction

Mammography is a specific type of imaging in which patients are more highly exposed than in other imaging tests, and routine mammograms have been performed and the images confirmed by a single radiological technologist (RT). "The Survey on Medical Fee" published in 2010 stated that 49% of additional mammography imaging was performed "under the judgment of an RT"[1)]. Therefore, the ability to convey an accurate diagnosis is necessary.

Nakayama et al.,[2)] reported that positioning errors in mammography imaging may lead to oversights or over diagnosis of breast cancer, and positioning is, therefore, a critical factor influencing the accuracy of mammography screening. Thus, mammography imaging quality is likely to depend on the ability of the RT. This ability is often associated with anxiety, especially for new, less experienced RTs.

In this study, we determined the factors underlying uneasiness for new RTs, developed and implemented measures to address these factors, and evaluated changes in RT anxiety.

1 Methods

1-1 Equipment used

- Senographe Essential Mammography device (GE Healthcare, Buckinghamshire, UK)
- Senographe DS Mammography device (GE Healthcare)
- Prescreening report
- Excel 2010 analysis software (Microsoft, Redmond, WA, USA)

1-2 Methods

The following 5 steps were followed to determine the cause of anxiety during mammography, to take measures to address those factors, and to evaluate the change in anxiety: (1) factors underlying anxiety during mammography were predicted using the brainstorming technique, (2) the work environment was examined with respect to each factor, (3) that factors that were unable to be resolved in the work environment were analyzed, (4) measures were taken to resolve those factors, and (5) anxiety was evaluated with respect to the implemented measures.

The details of this procedure are described below.

1-3 Extracting the factors underlying uneasiness in mammography using the brainstorming technique

Two new RTs (hereinafter referred to as RT-A and RT-B) were encouraged to express their opinions regarding factors causing uneasiness when performing mammography by brainstorming[3] in which they can freely express their opinions or ideas. In addition to RT-A and RT-B, an RT with 19 years of experience led the 30-minute brainstorming session.

A diagram of characteristic factors underlying anxiety experienced while performing mammography is shown in Fig. 1.

We classified the extracted factors into 5 categories: imaging technique, knowledge, device operation, environment, and team medical care.

1-4 Examining the work environment with respect to the extracted factors underlying uneasiness

We discussed a specific solution for each factor.

Anxiety regarding the imaging technique was resolved by developing a practice protocol that does not involve an actual patient.

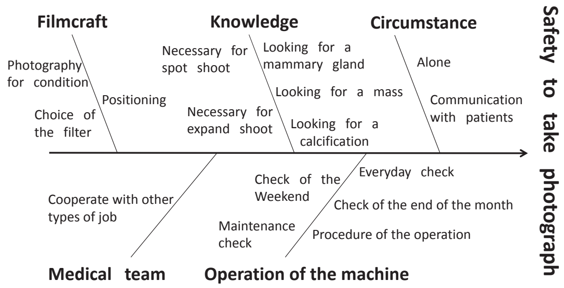

Fig. 1 Survey for anxiety that occurs during mammography.

Anxiety regarding team medical care was resolved by implementing active attendance at conferences on mammary tissue or mammotomes and the exchange of opinions among staff members. Anxiety regarding device operation was resolved by increasing the frequency of routine inspection or maintenance. Anxiety about the environment was resolved by establishing a system to facilitate contact between RTs and supervisors. However, no solution was determined to minimize anxiety related to knowledge; therefore, we conducted further study on this factor.

1-5 Analyzing the factors causing anxiety that were unable to be resolved in the established work environment

Kunugida[4] stated that the less knowledge an RT has, the more anxiety they feel, and improved knowledge is necessary to reduce the anxiety level. In this study, knowledge was indicated by reading ability, and the feeling of anxiety and prescreening ability were examined with respect to reading ability.

We analyzed the prescreening ability of each RT. The RTs were able to draw a scheme in the prescreening report, and put a mark in the appropriate columns for various categories, e.g., mammary parenchyma, calcification, tumor mass, and other findings (Fig. 2).

Analysis was conducted from July 2010 to March 2011. The right and left breast of each patient was counted as one case. Before training, RT-A experienced 39 cases and RT-B ex-

マンモグラム所見レポート

ID	
氏名	
生年月日	
撮影日	
撮影者	
読影者	

	AEC位置	S値	kV	mAs	体厚mm	圧迫圧daN	ターゲット/フィルタ
R-CC	1 2 3						
L-CC	1 2 3						
R-MLO	1 2 3						
L-MLO	1 2 3						

乳腺実質
□高濃度 □不均一高濃度 □乳腺散在 □脂肪性 □BCT後 □豊胸手術後

腫瘤（有・無）

部位	R・U M L・O I	L・U M L・O I
形状	円形 楕円形 多角形 分葉形 不整形	円形 楕円形 多角形 分葉形 不整形
辺縁	境界明瞭 微細分葉状 微細鋸歯状 境界不明瞭 スピキュラ状 評価困難	境界明瞭 微細分葉状 微細鋸歯状 境界不明瞭 スピキュラ状 評価困難
濃度	含脂肪 低濃度 等濃度 高濃度	含脂肪 低濃度 等濃度 高濃度

明らかな良性石灰化（有・無）

部位	R・U M L・O I	L・U M L・O I
形状	皮膚 血管 線維腺腫 乳管拡張症 円形石灰化 中心透亮性 石灰乳 その他	皮膚 血管 線維腺腫 乳管拡張症 円形石灰化 中心透亮性 石灰乳 その他

良悪性の鑑別が必要な石灰化（有・無）

部位	R・U M L・O I	L・U M L・O I
形態	微小円形 淡く不明瞭 多形性不均一 微細線状 微細分枝状	微小円形 淡く不明瞭 多形性不均一 微細線状 微細分枝状
分布	びまん性 領域性 集簇性 線状 区域性	びまん性 領域性 集簇性 線状 区域性

その他の所見（R・L）
□管状影 □非対称性乳房組織 □局所的非対称性陰影 □構築の乱れ □梁柱の肥厚
□リンパ節の所見 □皮膚の所見

カテゴリー分類	R：1 2 3 4 5 N1 N2	L：1 2 3 4 5 N1 N2

Fig. 2　Prescreening Mammography Report

perienced 57 cases. At the first training, RT-A read 35 cases and RT-B read 55 cases; at the second training, there were 40 cases for RT-A and 50 cases for RT-B; there were 32 cases for RT-A and 53 cases for RT-B at the third training session. As an analysis method, the prescreening reports created immediately after reading by both RT-A and RT-B were compared with the reading report created by a radiologist to calculate the accuracy rate. A proper diagnosis was counted when the classification of mammary parenchyma in the prescreening reports created by both RT-A and RT-B was consistent with the classification reported by the experienced radiologist. A proper diagnosis was also counted when all findings of calcification such as site, shape morphology, and distribution were consistent with the findings of the experienced radiologist. Furthermore, all findings of tumor mass such as site, shape, marginal, and density were required to be consistent with the findings of the experienced radiologist. The presence/absence of all other findings was required to be consistent with the findings of the experienced radiologist.

Accuracy rates for mammary parenchyma, classification, tumor mass, calcification, and other findings in the prescreening report are shown in Fig. 3.

Accuracy rates for mammary parenchyma, classification, and calcification ranged from 50% to 80% for both RT-A and RT-B, but the accuracy was less than 40% for tumor mass findings. Accuracy rates for other findings were 0% in RT-A and 36% in RT-B.

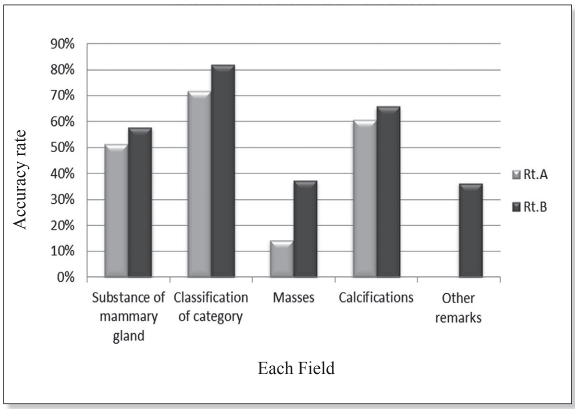

Fig. 3　Interpretation report accuracy rate of each primary

1-6 Measures to resolve the factors causing uneasiness that were unable to be resolved in the current work environment

Based on the analysis of the prescreening results, a textbook was created focusing on tumor mass owing to its low accuracy rate (Fig. 4 and 5). This textbook was created using the tumor mass diagnosis flowchart in "Mammography Guideline" [5] by extracting detailed diagnostic components and understandable explanations for terms from sources including "Asunaro Class for Mammography" [6], "Guide for Breast Cancer Screening using Mammography" [7], and "Mammography Technical Edition" [8]. When a tumor mass is diagnosed, the border/marginal is examined. At the end of the flowchart, a classification is assigned. Moreover, figures and photographs were used to facilitate understanding for beginners.

Mammography reading training was conducted on 20 to 40 cases per session using the images previously taken to accumulate knowledge, and the textbook was used as a reference.

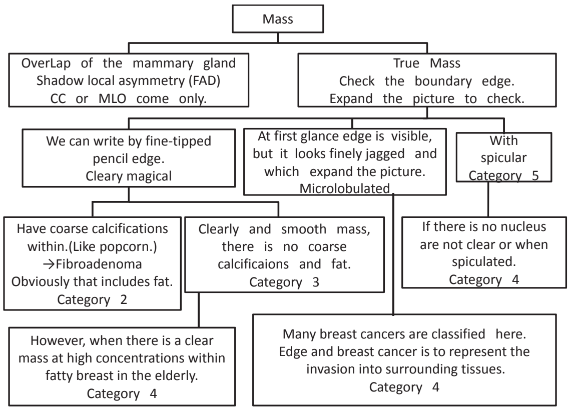

Fig. 4 Text that was created for training

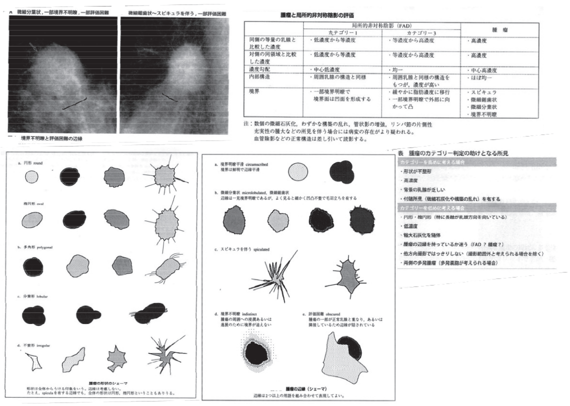

Fig. 5 Text that was created for training. No. 2[5~8)]

1-7 Evaluating changes in the anxiety level after measures were implemented

Mammography reading training described in Method 1-6 (hereinafter referred to as training) was conducted 3 times in sessions lasting 4 days. On completion of each training session, the change in the feeling of anxiety was evaluated.

A questionnaire was developed to calculate an anxiety index, and it was used to evaluate the correlation between the change in prescreening ability and the feeling of anxiety.

The questionnaire consisted of following 3 items: (1) anxiety about the classification system, (2) anxiety about determining the boundary edge of a mass, (3) anxiety about identifying a mass. Each item was scored on a scale of 1 to 5. A higher score indicates higher anxiety, while a lower score indicates lower anxiety and a gain in confidence. The anxiety experienced when entering the radiography room for the first time was rated as 5 points. RT-A and RT-B were asked to score their anxiety level according to this method. Each of the 3 items was evaluated.

The correlation between anxiety index and prescreening accuracy was estimated to determine the effect of mammography reading training on accuracy and anxiety. Spearman's rank correlation coefficient was calculated using Excel software[9)].

2 Results

2-1 Prescreening ability before and after training

The prescreening ability before and after training is shown in Fig. 6.

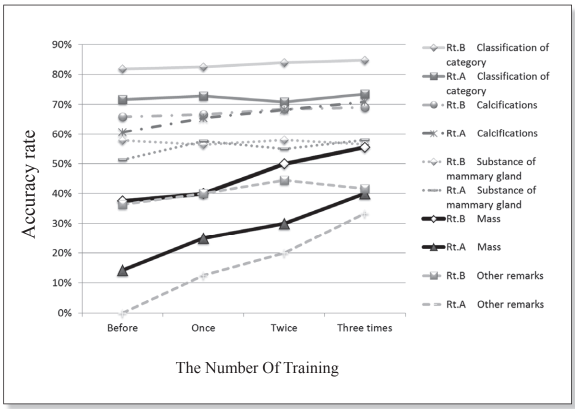

Fig. 6 Result about Prescreening

No significant improvement in the accuracy rate was observed for classification or mammary parenchyma findings after training compared to before training. For calcification, the accuracy rate of RT-A was 60.6% before training and improved by 10.2% after training, with a rate of 65.5% after the first training, 68.2% after the second training, and 70.8% after the third training session. RT-B demonstrated a

65.9% accuracy rate before training, and improved slightly but not significantly to 66.7% after the first training, 68.4% after the second training, and 69.0% after the third training session.

For the tumor mass field, the accuracy rate of RT-A was 14.3% before training, and increased after training, with an accuracy rate of 25.0% after the first training, 30.0% after the second training, and 40.0% after the third training session. Similarly, the accuracy rate of RT-B was 37.5% before training, and increased after training, with an accuracy rate of 40.0% after the first training, 50.0% after the second training, and 55.6% after the third training session.

For the other findings, consisting of architectural distortion of mammary glands and focal asymmetric density, the accuracy rate of RT-A was 0.0% before training and improved to 12.5% after the first training, 20.0% after the second training, and 33.3% after the third training session. The accuracy rate of RT-B was 36.4% before training, and improved slightly to 40.0% after the first training, 44.4% after the second training, and 41.7% after the third training session, though these improvements were not significant.

2-2 The changes in the anxiety index before and after training

The changes in the anxiety index for the assignment of categories before and after training are shown in Fig. 7. Anxiety indexes of RT-A and RT-B were 3.5 and 4.0, respectively, after the first training, and did not differ significantly compared to the indexes before training. However, they decreased to 3.0 for both RT-A and RT-B after the second training, and further decreased to 3.0 for RT-A and 2.5 for RT-B after the third training; thus, the index decreased by 0.5 and 1.5 for RT-A and RT-B, respectively.

The changes in anxiety indexes before and after training for the boundary edge of masses are shown in Fig. 8. Both RT-A and RT-B exhibited an anxiety level as high as 5.0 before training. The anxiety index of RT-A decreased to 4.0 after the first training, increased to 4.5 after the second training, and decreased to 3.0 after the third training. The anxiety index of RT-B decreased after repeated training.

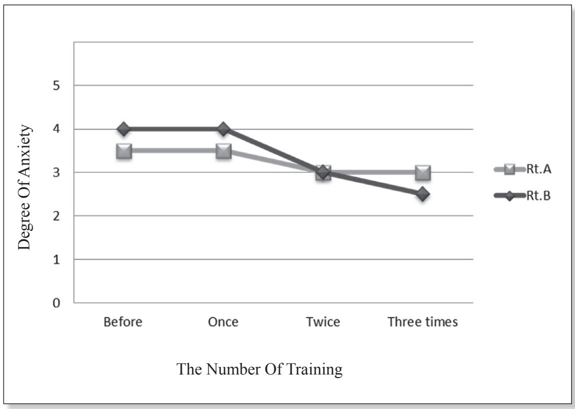

Fig. 7 Anxiety about the classification of category

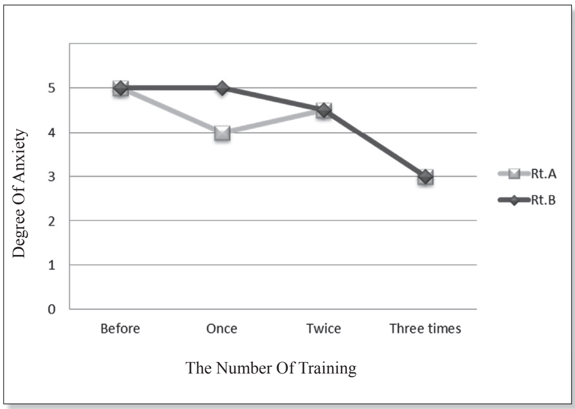

Fig. 8 Anxiety about the boundary edge of mass

The changes in the anxiety index for the identification of masses before and after training are shown in Fig. 9. Both RT-A and RT-B exhibited an anxiety level as high as 5.0 before training, and the anxiety index decreased to 4.5 after the first training, 4.0 after the second training, and 3.0 after the third training session.

We calculated the Spearman's rank correlation coefficient to test for an association between the prescreening accuracy rate before and after training and the feeling of anxiety. The estimated correlation coefficient was r_S = 0.755 ($p < 0.01$).

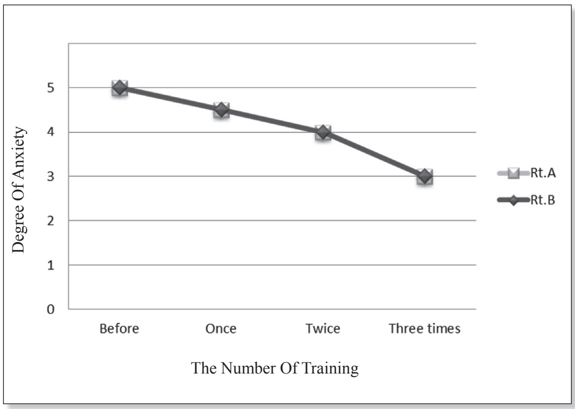

Fig. 9　Anxiety about the mass or not

A correlation coefficient that is close to one indicates a strong correlation[9]; therefore, a strong correlation was observed in this study between anxiety index and accuracy rate.

3 Discussion

The experience of performing the imaging test alone and confirming/determining many types of images is valuable for new RTs. In mammography, minimizing anxiety is particularly important. In this study, we examined whether training could reduce anxiety in new RTs during mammography.

In the training sessions, RTs were required to determine tumor mass, calcification, and other findings to determine the appropriate classification. In this study, no significant difference was observed in the ability to determine calcification before and after training. Tumor mass was considered the most critical factor affecting the accurate classification and a significant difference in accuracy was observed before and after training.

The total number of cases and the number of cases for each classification are shown in Table 1.

When multiple findings were observed for a particular case, each finding was counted as one case. The number of reading cases varied for each training session, ranging from 32 to 40 cases for RT-A and 50 to 57 cases for RT-B. The number of tumor mass cases ranged from 5 to 10 for RT-A and 5 to 9 for RT-B, which represented only approximately 18% of the total cases and thus may have had little influence on the observed changes.

Table 1　The Number of cases in each field

	Before	Once	Twice	Three Times
Rt.A All Cases	39	35	40	32
Rt.B All Cases	57	55	50	53
Rt.A Mass	7	8	10	5
Rt.B Mass	8	5	8	9
Rt.A Calcifications	33	29	22	24
Rt.B Calcifications	41	36	38	29
Rt.A Other Remarks	8	8	10	6
Rt.B Other Remarks	11	10	9	12

For tumor mass findings, the prescreening accuracy rate before training was low. The linear attenuation coefficient for mammary gland and tumor tissue was almost same at 0.80 and 0.85, respectively[10], making it difficult to enhance contrast. Therefore, the images could be difficult to read for new, less experienced RTs. After repeated training using a textbook produced for this study consisting of a detailed flowchart, the reading experience points of the RT who was not familiar with mammography reading increased, and the accuracy rate improved by obtaining the improved reading techniques. It has been reported that repeated reviews are efficient for the acquisition of memories[11]; thus, repeated reading training over a short time span contributed to knowledge acquisition in this study.

For the calcification field, the accuracy rate was not significantly different before and after training. This may be because the reading of calcification was easier than that of other fields, with a linear attenuation coefficient as high as 12.5[10], which means its contrast is more intense compared with other mammary tissues.

For other findings such as architectural distortion and focal asymmetric density, the accuracy rate of RT-A was 0.0% before training, and improved to 33.3% after the third training session. This improved accuracy may reflect the initial lack of knowledge for RT-A at the beginning of the study and the gain in knowledge by repeating training.

RT-A and RT-B showed a similar clinical experience, which was expressed by the change in the overall accuracy rate in performing mammography. However, the change in the accuracy rate of RT-A was bigger than that of RT-B. RT-B attended a mammography certification test hosted by the Japan Central Organization on Quality Assurance of Breast Cancer Screening before training; thus, RT-B may have gained more knowledge on mammography than RT-A. Education via the training sessions was also an efficient way to acquire knowledge.

The prescreening ability was improved by repeated reading training while the anxiety index was decreased. The analysis of the prescreening report showed that RT- A and RT-B lacked experience and knowledge in the tumor mass field. However, they were able to gain knowledge efficiently through training that focused on a certain subject. Mihai et al.[12] reported that the more knowledge or a greater depth of understanding were associated with a lower level of anxiety. Similarly, acquiring knowledge by reading training may have led to the decrease in the anxiety level in this study.

As a training method, a textbook was created focusing on the tumor mass field based on a prior analysis, and its use may have led to the observed decrease in anxiety. Therefore, it may be important to understand the weaknesses of the RTs at each institute to create an appropriate textbook.

The results of this study showed that the prescreening ability of RTs improved by investigating the factors underlying the anxiety in performing mammography. Koyama et al.[13] reported that a high prescreening ability of RTs in mammography is important because the imaging position affects the reading in clinical practice; therefore, training on radiological techniques may have a favorable effect on both RT and patient.

4 Conclusion

Training using a textbook successfully reduced anxiety during imaging experienced by single RTs. The importance of the prescreening ability of clinical radiologists was also indicated in this study; thus, we will make an effort to improve the reading ability by providing additional training in the future.

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Diagnostic Reference Level (DRL) in the CT of Gunma

Hiroyuki Takei[1),] Hidenori Otake[1),] Yoshito Tsushima[2),] Keigo Endo[3)]

1) Department of Radiology Gunma University Hospital
2) Department of Diagnostic Radiology and Nuclear Medicine Gunma University Graduate School of Medicine
3) Kyoto College of Medical Science

Key words: DRL (diagnostic reference level), CT (computed tomography), CTDI (CT dose index), DLP (dose length product)

【Summary】
As a regional to take a medical statistics, Gunma Prefecture is one of the region, such as Japan's leading. There is 1.7% of the area of Japan, the population is also 1.7%. The number of doctor is 230 persons per 100,000 people, which is the same as the entire Japan.
The purpose of this study is to derive the diagnostic reference levels (DRL) of CT scan in Gunma prefecture. DRLs derived from scan parameters of each units were in 75 percentile values, 115.6mGy for head CTDIw and 35.0mGy for abdominal CTDIw. Compared to DRLs in the EU, values were 1.9 times larger in the head, and were equal to EU values in the abdomen.

1. Diagnostic Reference Level (DRL)

The diagnostic reference level (DRL) is an index used in medical imaging to quantitatively analyze the radiation dose received by a patient or the administered radiation (i.e., the quantity of radioactive substances) for a given imaging method[1)].

In practice, DRL values are selected based on percentile scores for the observed radiation dose distribution for multiple patients or a given reference patient. DRL values should be selected by professional medical groups working with national insurance and radiation protection authorities. They should be periodically reviewed at appropriate intervals with respect to the required stability and long-term changes in the observed dose distribution. Selected values can be country- and region-specific.

2. Purpose

This study surveyed CT scans performed in Gunma prefecture, Japan (in June 2009). We recorded the number of scans, the scan location, and exposure dose for each scan to determine the exposure dose distributions. We compared these estimated distributions with previously reported DRL values for the European Union (EU)[2)] . The DRL indices were the weighted CT dose index (CTDIw) and the dose-length product (DLP).

For data sets containing outlier values, we also considered DRL distributions that excluded outlier values for our comparative analyses.

3. Methods

Questionnaires we sent to all medical facilities in Gunma prefecture that have CT scanners. Respondents were asked to provide information regarding the scanner model and the standard scan conditions used for adults. They were also asked to list the age, sex, scan location, and number of scans received for each patient scanned in June 2009.

The CTDIw and DLP values for the scan

conditions provided were calculated using ImPACT CT Patient Dosimetry Calculator Version 0.99x (see www.impactscan.org). The results are presented using histograms and the dose distribution data was used to estimate the DRL values obtained for each of the CT scanners in Gunma prefecture. We indicate the DRL values using histograms of measured values that show the mean, 25th percentile, and 75th percentile. We compared these values with DRL values reported for the EU.

4. Results

We requested information from 193 hospitals (including clinics and other facilities) that had a total of 198 CT scanners. We received responses from 76 hospitals (39%) with a total of 81 scanners (41%).

A total of 16,915 patients received CT scans at these hospitals during the one-month period surveyed. We classified scan locations as the head, face, neck, chest, upper abdomen, and lower abdomen (pelvis). Many patients

Table 1 Number of patient, CT examination and scanning

	men	women	Total
Number of patient	9,343	7,572	16,915
Number of CT examination	15,287	12,288	27,575
Number of scanning	20,917	16,518	37,435

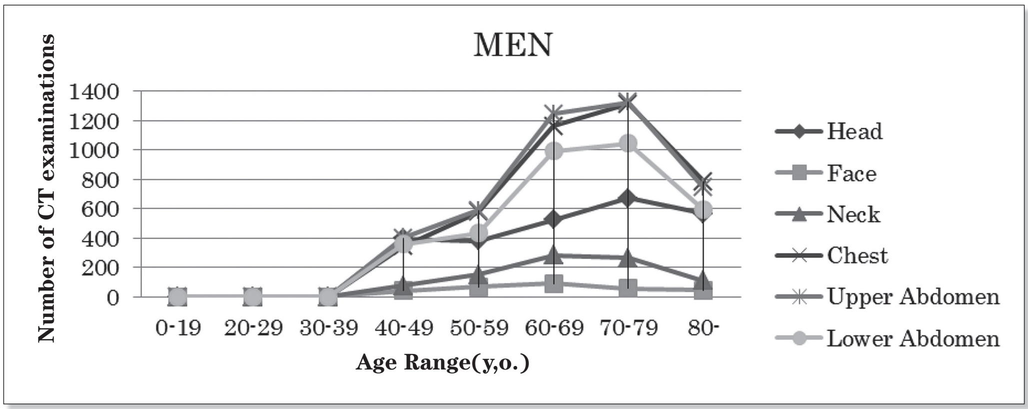

Fig. 1 Number of CT examinations for each age range and anatomical locations scanned (for men)

Fig. 2 Number of CT examinations for each age range and anatomical locations scanned (for women)

received scans of multiple locations in a single session. Taking these scans of multiple locations into account, the total number of scans was 27,575. Accounting for multiple scan types (for example, plain scans and contrast-enhanced scans), the total number of scans was 37,435. Table 1 and Fig. 1 and 2 show the data for men and women.

Fig. 3 and 4 show the CTDIw and DLP distributions for each scan location.

Tables 2 and 3 and Fig. 5 and 6 show the Gunma prefecture DRL values, (i.e., CTDIw and DLP) calculated from these data along with the corresponding EU values. The head and face CT scan results contained clear outlier values, which were excluded from the analysis.

5. Discussion

The value corresponding with the 75th percentile was used as the DRL value, consistent

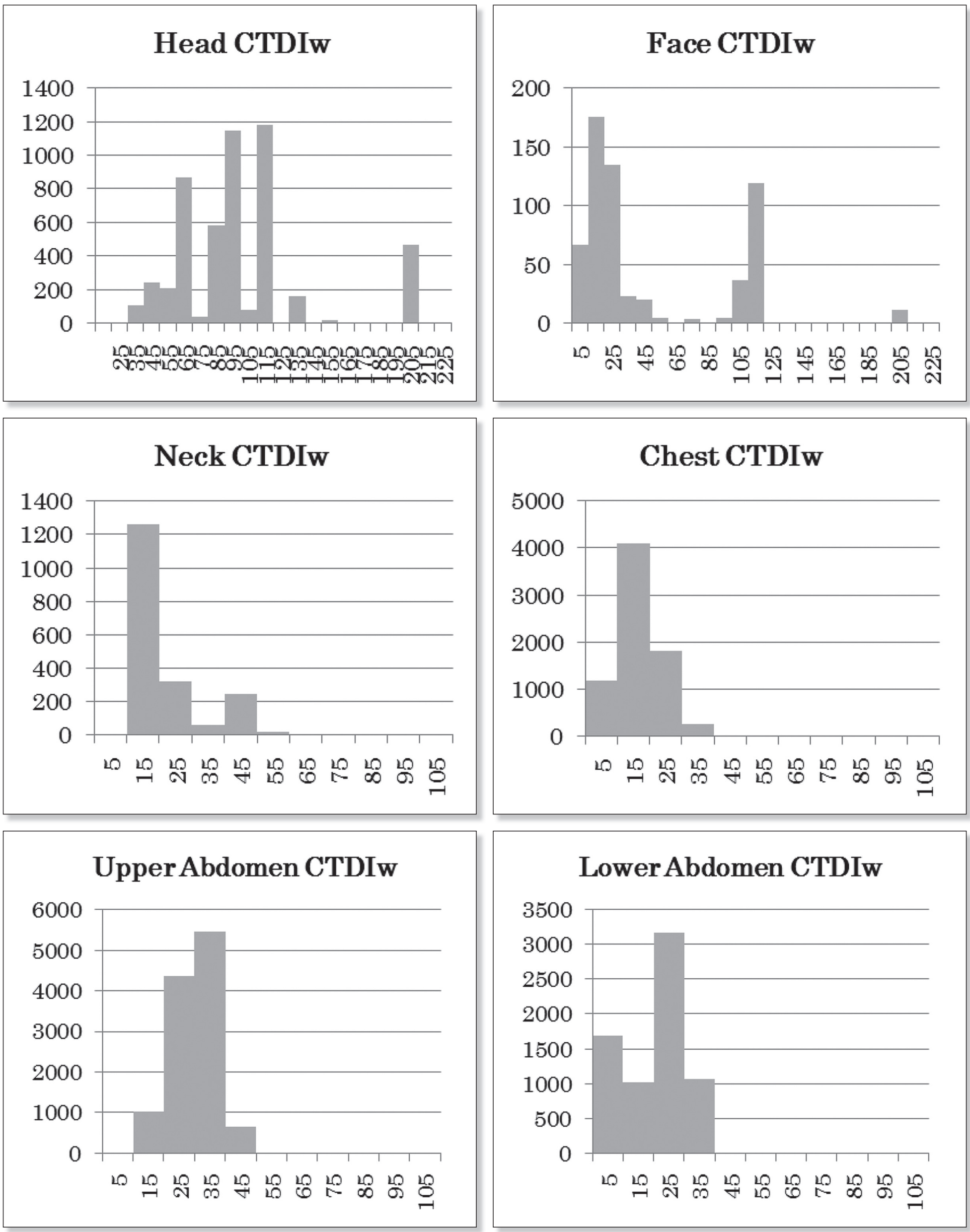

Fig. 3 The distribution of CTDIw for each anatomical locations
(The vertical line represents Number of CT examinations, the horizontal line represents CTDIw (mGy))

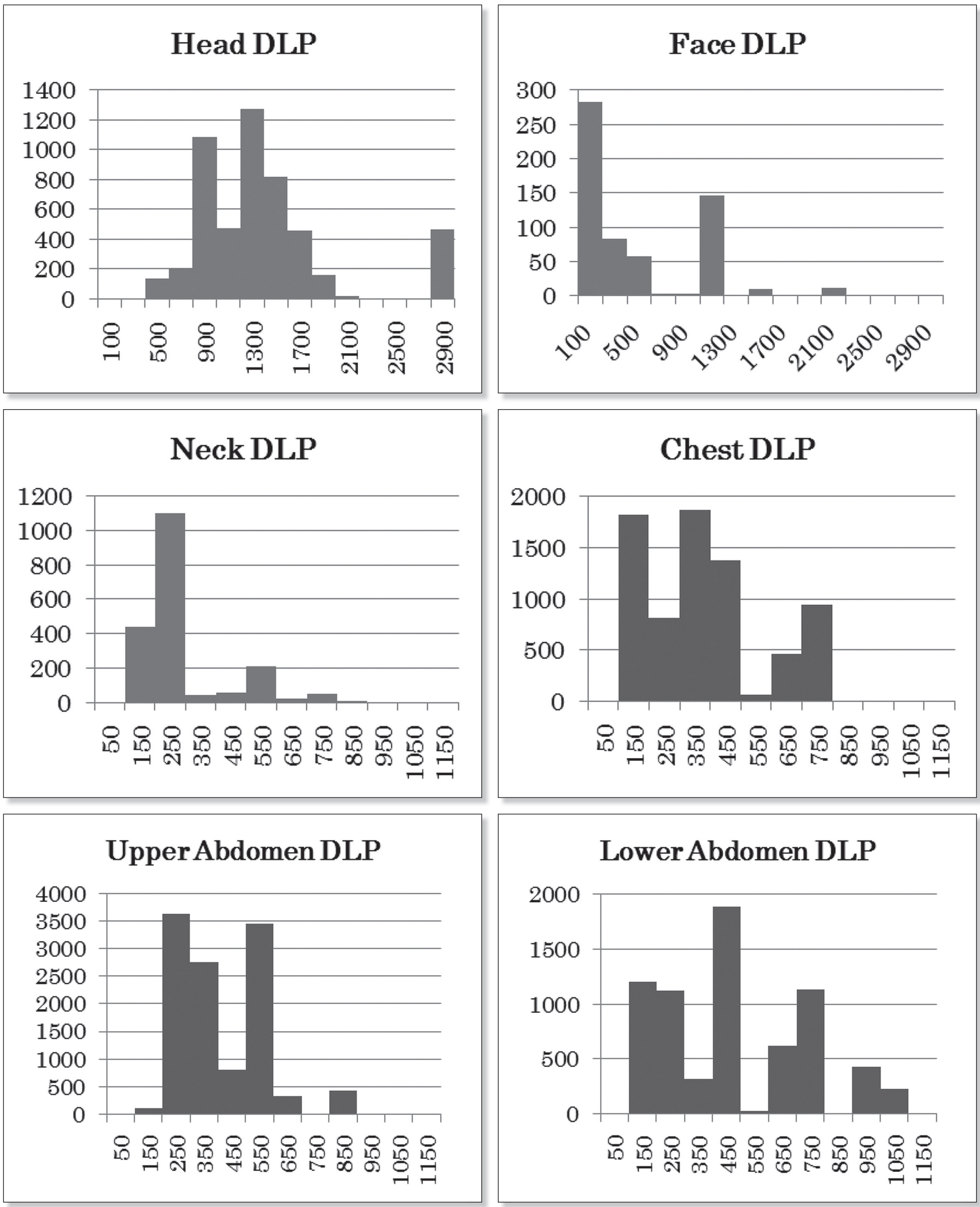

Fig. 4 The distribution of DLP for each anatomical locations
(The vertical line represents Number of CT examinations, the horizontal line represents DLP (mGy・cm))

Table 2 Diagnostic Reference Level (DRL) in Gunma (CTDIw : mGy)

CT examination	25%	75%	EU	25%	75%
				Excluding outliers	
Head	82.1	137.3	60	82.4	115.6
Face	26.9	91.1	35	8.3	50.6
Neck	24.1	39.8	70	–	–
Chest	21.7	31.4	30	–	–
Up Abdomen	25.0	35.0	35	–	–
Lower Abdomen	23.3	37.1	35	–	–

with previous studies in other locations. Expressed relative to the corresponding EU values, the Gunma CTDIw and DLP values were as follows (respectively): 1.9 and 1.4 for head scans, 1.5 and 2.4 for face scans, 0.6 and 1.1 for neck scans, 1.1 and 0.7 for chest scans, 1.0 and 0.7 for upper abdomen scans, and 1.1 and 1.2 for lower abdomen scans.

While the CTDIw and DLP data for nearly all scan types meet the EU DRL standards for

Table 3 Diagnostic Reference Level (DRL) in Gunma (DLP : mGy・cm)

CT examination	25%	75%	EU	25% Excluding outliers	75% Excluding outliers
Head	955.5	1662.3	1050	963.9	1505.9
Face	337.5	926.1	360	345.5	849.8
Neck	292.8	520.9	460	–	–
Chest	251.3	475.3	650	–	–
Up Abdomen	290.2	529.8	780	–	–
Lower Abdomen	304.1	653.2	570	–	–

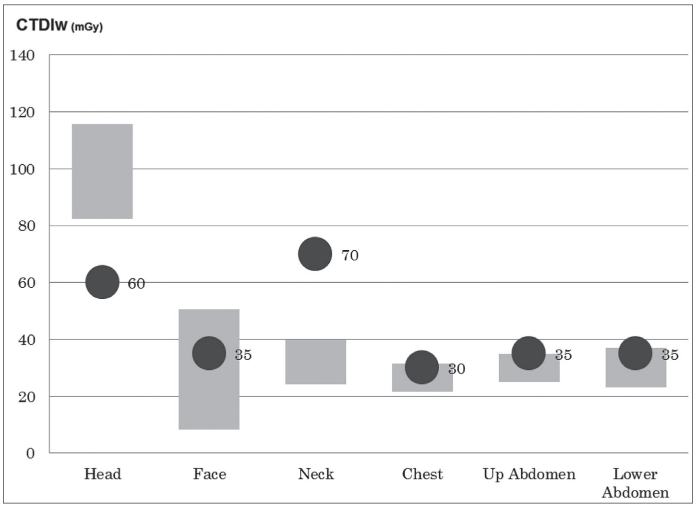

Fig. 5 Diagnostic Reference Level (DRL) in Gunma (● : EU)

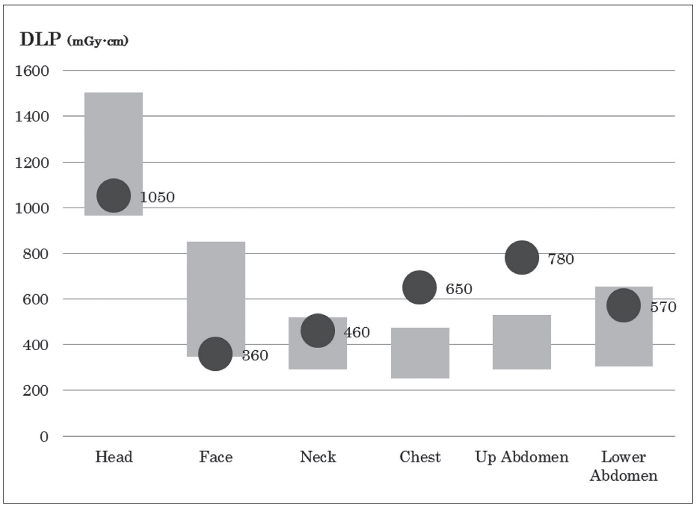

Fig. 6 Diagnostic Reference Level (DRL) in Gunma (● : EU)

chest and upper/lower abdomen scans, the observed exposures for head and face scans were significantly higher than the EU standards, ranging between 1.4 and 2.4 times the EU values even when clear outliers were excluded.

The Japan Association of Radiological Technologists' 2006 X-ray guidelines for adult CT scans[3] set a CTDI value of 65 mGy for head scans and 20 mGy for abdomen scans (equivalent to 22 mGy for 32-cm diameter acrylic phantom). Our results were between 1.6 and 1.8 times higher than either of these values.

CT scans with higher patient exposure doses usually have better picture quality, so the excessive values observed for Gunma prefecture facilities relative to those of EU facilities does not directly imply that these doses are inappropriate. They may be necessary to create the picture quality demanded.

Since the EU DRL standards were set in 1999, they are now over a decade old and may not reflect current conditions. However, a recent survey of DRL values for CT scans in Korea[4] found a CTDIw of 62.4 mGy for head scans, showing that many scanners have DRL values lower than those of the EU.

Moreover, the large number of unusable responses we received indicated that we did not adequately communicate the purpose of the questionnaire or the directions for participation, so additional, improved survey methods will be needed in the future. One factor that affected the survey results was the calculation methods, which were based on summary statistics that did not account for individual variation. While many different patient conditions exist in practice, each calculated value was obtained from a single scan condition for a single scanner and scan location. Estimating exposure doses according to each set of patient conditions will result in more reliable results in the future.

Defining the DRL as the 75th percentile value, as is done overseas, enables the determination of an index value purely for the purpose of reducing exposure; however, we believe that considering both the 25th and 75th percentile values is needed to balance exposure reduction and picture quality requirements.

6. Conclusion

We determined the CTDIw and DLP values and therefore the DRL for CT scanners in Gunma prefecture in 2009. We presented both the 25th and 75th percentiles for DRL.

We found that chest and upper/lower abdomen scans were similar to those reported in the EU, but values for head and face scans ranged from 1.4 to 2.4 times higher. The effects of survey method, facility differences, educational differences, and other factors are topics that will require detailed studies in the future.

7. Acknowledgments

This study was assisted by the 'Endo Team' Grant-in-Aid for Cancer Research provided by the Ministry of Health, Labour and Welfare. We would also like to express our sincere appreciation for the efforts of the staff and technicians at Gunma prefecture's medical facilities with CT scanners.

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2) Quality Criteria for Computed Tomography. EUR 16262, EC, 1999.
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Development and Operation of an Image Interpretation Training System

Hironobu Tomita

Saitama Association of Radiological Technologists

1. Background

On April 30, 2010, Health Policy Publication No. 0430, "Concerning the promotion of team medicine by means of cooperation and collaboration between medical staff" was issued by the Ministry of Health, Labour and Welfare. Its basic concept is that "In order to provide high-quality medical care alongside patients and their families that utilizes the expertise of specialized medical staff, it is important to refer to the general instructions issued by doctors and others, with the medical staff sharing a common objective and information as a team, proactively contributing their own specialist skills while increasing the level of collaboration and complementation between them." Our role as radiological technologists is expanding in terms of taking on tasks in areas including radiological treatment, tests, and management, as well as imaging tests. As specialists in these tasks, this means that we may be able to play increasingly major roles in clinical settings. In terms of the proactive utilization of clinical radiological technologists, two tasks will be required: assisting with the interpretation of diagnostic images and providing explanations and advice concerning radiological tests.

2. History of Image Interpretation Training by the Saitama Association of Radiological Technologists

The Saitama Association of Radiological Technologists has been engaged in image interpretation training and content production for more than a decade, and has made these widely available to its members through seminars and other means. We have also held film-reading contests at the Saitama Radiology Conference, initially by setting up an area for displaying and interpreting films on mammography and upper gastrointestinal scans on a film viewer. Ultrasound interpretation using a poster format was subsequently added and since 2006 the display has also included X-ray CT scans. This involves using a laptop computer to manage DICOM images and a viewer on a single CD-R using a program developed by our group, a standalone program for individual computer users and the first to provide a monitor-based image interpreting environment.

We are also developing a system to certify radiological technologists. At present, the Saitama Association of Radiological Technologists offers certification in chest X-rays, upper gastrointestinal scans, and X-ray CT scans. The system was launched in 1999 with three modalities: chest, upper gastrointestinal, and mammography. Recent trends mean that it is now possible to take the Common Examination of the Central Committee on Quality Assurance of Breast Cancer Screening in regional centers, and for this reason the 3 modalities now comprise chest, upper gastrointestinal, and X-ray CT (added in 2009). The certification standards for each modality are listed below. When the scores for tests of interpretation, notation, and image evaluation (for the upper gastrointestinal modality only) differ, the lower score is used to decide the certification grade. For example, a candidate with a score of 95 points for interpretation and 73 points for notation would be certified as Grade B, and a candidate who scored 80 points for interpretation, 90 for notation, and 60 for image evaluation would be certified as Grade C.

Certification Standards

Chest

Grade A: 90 points or above in both sections (interpretation/notation)
Grade B: 70–89 points
Grade C: 69 points or less

X-ray CT

Grade A: 90 points or above in both sections (interpretation/notation)
Grade B: 70–89 points
Grade C: 69 points or less

Upper gastrointestinal

Grade A: 90 points or above in all sections (interpretation/notation/image evaluation)
Grade B: 75–89 points
Grade C: 74 points or less

To qualify for certification, candidates must be competent in interpretation as well as in notation, and will not be certified if they do not score above the requisite standard in both areas. This is based on the idea that in addition to thorough familiarity with the device and quality control, interpretation is an essential skill to determine the quality of clinical images in order to provide images that are clinically useful. We have already conducted seminars and certification tests that are directly related to clinical tasks. Several clinical radiological technologists take these tests every year. Certified radiological technologists are issued with an individual certificate of certification, and their names and affiliations are published (with their permission) on the website of the Saitama Association of Radiological Technologists. Please see http://www.sart.jp/member2005/ for more details.

3. Development of a new image interpretation training system

In recent years, more hospitals have moved to filmless, monitor-based diagnostics, and the necessity for a new image interpretation training system has become apparent. Image interpretation is a skill for which training is most widely needed for radiological technologists and previous systems that used film viewers entailed significant cost and labor in terms of handling, preparation, and other tasks. These methods also presented major challenges with regards to the deterioration of teaching films over time and handling. Recent years have also seen dramatic advances in the use of electronic clinical image data, and it was suggested that developing this system would enable the use of mammography, upper gastrointestinal, CT, and chest X-ray scans. We began development jointly with Doctor-NET, a remote diagnostic imaging company, in June 2012. The basic concept was to develop a system that could provide a reading environment on a regular monitor and which could be used at conferences and other events nationwide, with simplification and streamlining of content production and operability taken into consideration.

4-1. System Overview

In light of the above, we developed the system illustrated in Fig. 1. Its characteristics can be outlined as follows. Image data for interpretation can be uploaded to a cloud-based server as raw DICOM data by each workshop leader. As long as internet access is available, the leader can upload images from anywhere in Japan. This improves operating efficiency and enables teaching files to be managed online. An application virtualization system is used to distribute the images to client computers at conference venues and elsewhere, meaning that the DICOM images themselves are not downloaded. This reduces the amount of bandwidth required, ensuring fast responsiveness on any terminal. The recommended minimum transmission speed between the server and client computers is around 10 Mbps.

4-2. Virtualized application

Fig. 2 shows an outline of the system. This is an image forwarding-based application using an environment based on Windows terminal service (TS) and remote desktop service (RDS), with enhanced security, performance, extensibility, stability, and flexibility, among other advantages. The major advantage of this system is that the desktop application and client software that earlier had to be installed on the client terminal before use, are installed and run on the server, with only the application's screen images displayed on the desktop of the client terminal. The user operates the software remotely by using a keyboard and mouse. An environment is thus created in which the application is completely virtualized, just as if it were being operated on the client terminal. This clear separation of the environment in which an application is run from that in which it is used is a key feature of virtualization. It has a range of advantages, including enabling the uniform management of the client environment, assuring security by means of functions such as Secure Socket Layer (SSL) or a Virtual Private Network (VPN), eliminating the need for a dedicated thin client terminal and guaranteeing ease of operation to a certain extent, even if network connections are not optimal. Security is extremely important for medical images and as data are never copied onto a client terminal they can be aggregated and protected at a single location. The fact that the application is virtualized also means that installation and maintenance are performed on a single server, enabling instant delivery to the user, reducing the amount of management required and dramatically improving the flexibility and speed of response

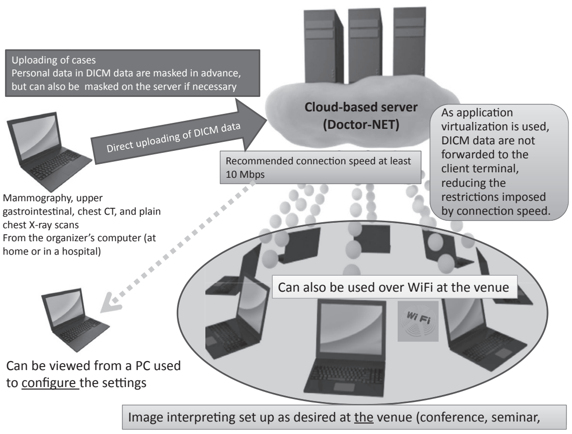


Fig. 1.

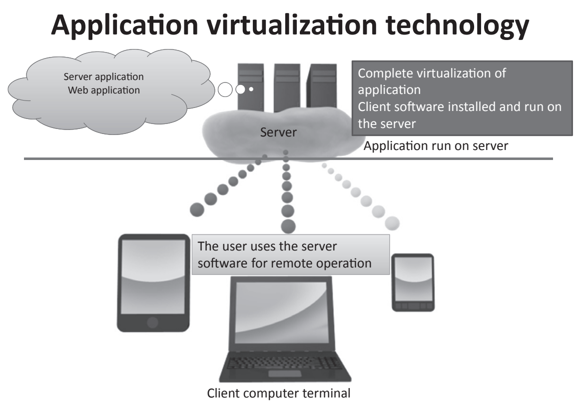


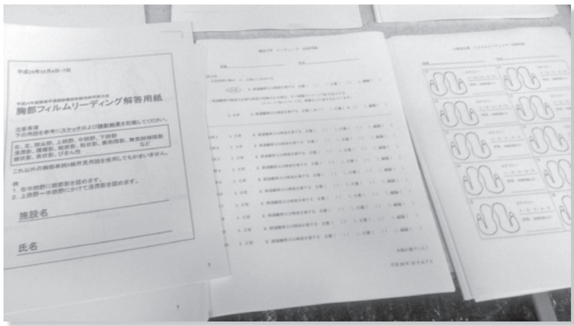
Fig. 2.

of information technology.

4-3. Steps to create questions

Actual case registration can be performed by uploading to the server from a personal computer, on which the settings have already been made. When uploading DICOM data, ideally a rewritten version of the patient's personal information should already have been uploaded, but if this is not possible then personal information can be masked after uploading through a simple operation. Fig. 3 shows the sequence of operations. Large numbers of cases can also be uploaded to the image server, and packages can easily be created or selected for use at conferences, seminars, or other events. Fig. 4 shows the sequence of operations for the easy creation of questions on interpretation.

Participants engaged in image interpretation



Photograph of the answer sheet

Image tag editing tool

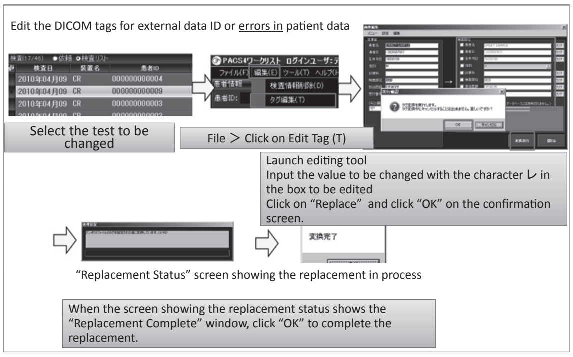


Fig. 3.

Creation of image interpretation packages

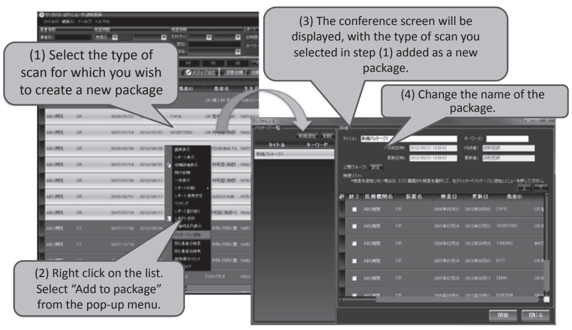
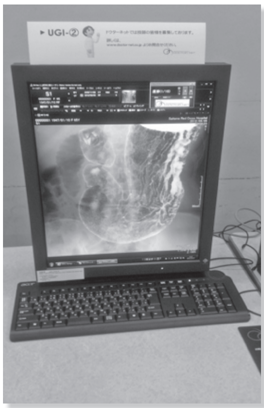


Fig. 4.

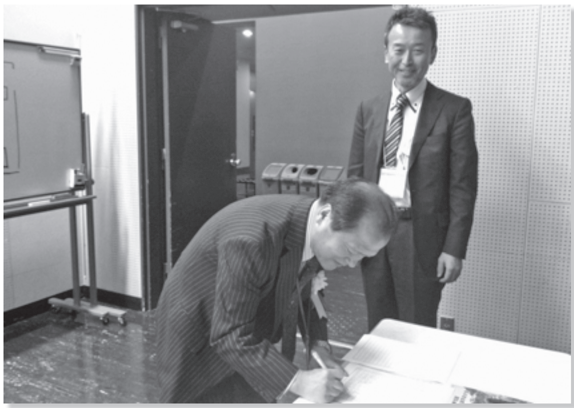
5. Initial use

The 2012 Kanto Koshinetsu Clinical Radiology Conference was held in Ibaraki Prefecture on October 6th and 7th, 2012. During the conference, 10 cases each, of chest CTs, plain chest X-rays, upper gastrointestinal scans, and mammography scans were prepared to allow for interpreting experience, and the monitor interpreting environment was used for the first time. Three devices were set up for viewing CT images, 2 for plain chest X-rays, 3 for upper gastrointestinal scans, and 2 for mammography scans. The participants filled in their findings on an answer sheet while viewing the images on the image viewer and were provided with the correct answers after they had finished. The event was very popular, with over 70 people participating over the 2-day period. Photographs taken on the day are reproduced below.



Upper gastrointestinal case

Chest X-ray case



Yasuo Nakazawa, President of the Japan Association of Radiological Technologists, also had a go at image interpretation!
Right: Koichi Horie, Vice-President of the Saitama Association of Radiological Technologists.
Writing: Yasuo Nakazawa, President of the Japan Association of Radiological Technologists

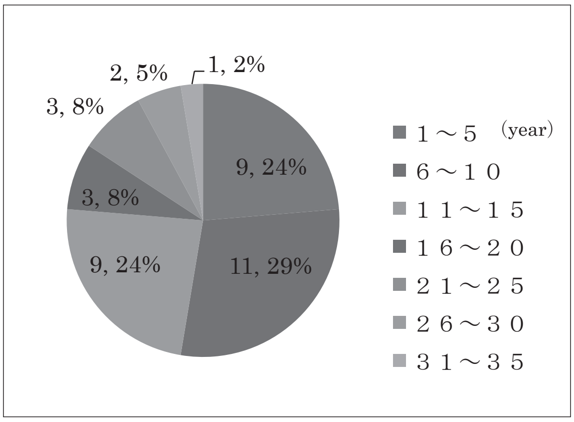


Fig. 5. Number of years of experience of technologists who took part in image interpretation.

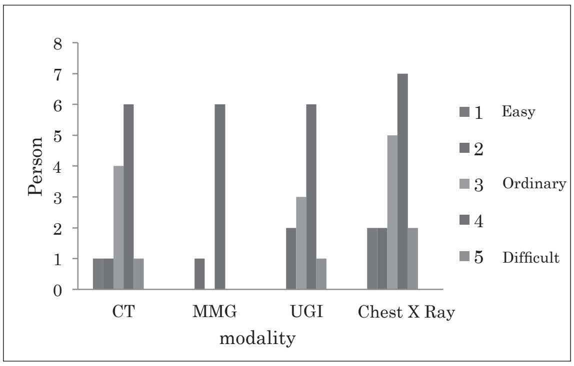


Fig. 6. Degree of difficulty by modality.

6. Questionnaire for participants

The results of a questionnaire completed on the day by participants who attempted the interpretation questions are shown below. As shown in Fig. 5, approximately half of the radiological technologists who took part had less than 10 years of experience and interest was greater among younger technologists than that among veterans. As shown in Fig. 6, level 4 was the most common level of difficulty across all the modalities and many participants expressed the opinion that the questions were difficult.

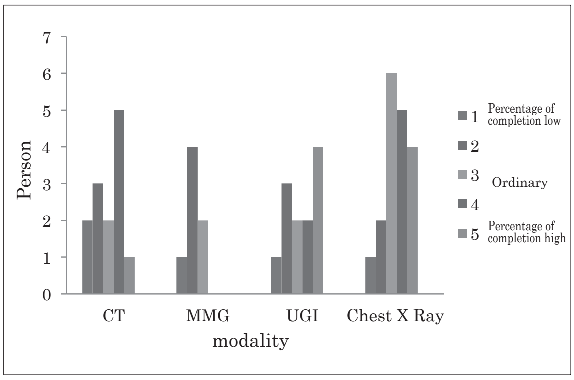


Fig. 7. Extent of completion of image interpretation viewer by modality (including speed).

As shown in Fig. 7, an evaluation of 3 was generally appropriate in most cases and the fact that no participant achieved an evaluation of 4 or 5 for mammography scans alone can be explained by the fact that the internet connection speed was only 8 Mbps, meaning that the response time for W.W adjustment and zooming in and out was poor. This result correlates with the developer-recommended speed of 10 Mbps and would improve with a better connection speed.

7. Conclusion

In this article, I have described the training in image interpretation offered by the Saitama Association of Radiological Technologists, its development, and its attributes as a new initiative. We intend to make every effort to contribute to further improving the image interpretation skills of clinical radiological technologists in future. The photograph below shows some of the members involved in implementing this new initiative.

Acknowledgments

We would like to express our gratitude to the staff of Doctor-NET, the company involved in the joint development of this system.

Top row, left to right: Yosuke Kidokoro, Kiyoshi Ogawa, Koichi Horie, Hiroshi Tanaka, Kan Yokoyama.
Bottom row, left to right: Hironobu Tomita, Satomi Hashimoto

Fundamental Study of easy decision method for Optimization of Exposure Dose in Computed radiography.

Yasuo Mochizuki[1) Shinji Abe[2) Toshiaki Adachi[3) Masahiko Monma[2) Kojiro Yamaguchi[4)

1) Department of Radiological Technology, Faculty of Health Sciences, Nihon Institute of Medical Science.
2) Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences
3) Department of Radiology, University of Fukui Hospital
4) Faculty of Radiological Technology, Fujita Health University School of Health Science

Key words: computed radiography (CR), Wiener spectrum (WS), root mean square (RMS), exposure dose, threshold

【Abstract】

The optimum dose for a computed radiography system (CR) was estimated from the relationship of the radiation dose to the root mean square (RMS) and the Wiener spectrum (WS).

Samples for analysis of noise characteristics were prepared using a 50.0 mm tough water phantom, as a scattering body, fitted with a 20.0 mm Al filter (SID 200 cm, tube voltage 80 kV). The dose level at which the film density in the standard screen-film system was 1.0 ± 0.05 was adopted as the criterion dose (23 mGy) and five samples were prepared at dose levels of 1/4, 1/2, 1, 2 and 4 fold relative to the criterion dose.

RMS was calculated from five 256 × 256 pixel images. WS was determined from the 320 segments yielded by two-dimensional fast Fourier transformation (2DFFT) of the 256 × 256 pixel images.

On the basis of the data on RMS and WS, the optimum dose was determined, with the threshold level defined as the point of intersection in linear approximation between the low dose range affected by the quantum mottle and the high dose range depending on the system noise. As a result, the dose for CR, determined from RMS and WS, was about 30% lower than the screen-film system criterion dose.

Introduction

The digitization of X-ray systems and general imaging devices has led to a shift from intensifying screens and the screen-film system (S/F system) to computed radiology (CR), flat-panel detectors (FPDs), and other types of digital radiography (DR).

The imaging conditions of the S/F system require that the operator select the sensitive material based on the site to be imaged, making its sensitivity the decisive factor. However, DR obtains accurate density using automatic compensation mechanisms. Thus, unlike the S/F system, DR has no concept of sensitivity as an important factor to match the imaging conditions[1)]. As a result, although the X-ray imaging conditions are assumed to be based on standard doses used in the S/F system, no systematic method of setting appropriate imaging conditions exists, which makes the determination of imaging standards difficult. An ICRP report[2)] has pointed out the problem of higher doses being used for DR X-ray imaging than those used for the S/F system, and the standardization of imaging conditions is being attempted.

Comprehensive evaluations of the S/F system based on physics have been carried out using the noise equivalent quanta (NEQ)[3)] which is the squared signal-to-noise ratio (SNR). Since there is no sensitivity index for DR, it has been proposed[1)] that the detective quantum efficiency (DQE)[4)], which is the ratio of the squared output SNR and the squared input SNR, be used.

DQE is obtained using the ratio of the average number of photons absorbed per unit area for the purpose of forming an image on the DR device and the number of incident photons, which reveals photon detection efficiency. In an ideal imaging system in which all the incident photons are used for image formation, DQE would be 1. Thus, the noise characteristics directly affected by an imaging dose according to the NEQ denominator may be useful as a factor for determining DR imaging conditions. However, there are no studies one the investigation of a method for determining the imaging dose according to the root mean square (RMS) and Wiener spectrum (WS), which are used as indices to evaluate the incident dose and noise characteristics.

The authors have proposed an estimator to determine the imaging dose that estimates the threshold from the relationship between the visual evaluation method, known as the image quality figure (IQF)[5,6], and the CR exposure dose (hereafter referred to as imaging dose)[7]. However, it has been difficult to prepare specimens for visual evaluation and analyze experimental observations.

The present study focuses on the relationship between imaging dose and noise, and reports on our investigation into a simple method for determining the CR imaging dose with the threshold level for the optimum dose for X-ray images with a good balance between image quality and dose. This balance point is defined as the point of intersection in linear approximation between the low dose range affected by the quantum mottle and the high dose range that depends on the system noise. We also performed visual evaluations of the S/F system and CR image quality by calculating the detection ability of the area under the curve (AUC) of the receiver operating characteristics (ROCs) using the S/F system and CR hard copies (film) created according to the S/F system imaging dose standards using acrylic bead signals.

1. Imaging dose and noise characteristics

NEQ was defined as the output (SNR)^2 value, and DQE was defined as the ratio between input and output (SNR)^2 values using the following formulas:

$$NEQ(u) = \frac{(\log_{10} e)^2 \cdot G^2 \cdot MTF(u)^2}{WS(u)} \quad (1)$$

$$DQE(u) = \frac{(\log_{10} e)^2 \cdot G^2 \cdot MTF(u)^2}{q \cdot WS(u)} \quad (2)$$

In these formulas, u is spatial frequency, $(\log_{10}e)$ is the density conversion coefficient, G is the gradient, and q indicates the average number of incident photons per unit area. The WS of the quantum mottle was provided by the following formula[8]:

$$WS(u) = \frac{(\log_{10} e)^2 \cdot G^2 \cdot MTF(u)^2}{\bar{n}} \quad (3)$$

In this formula, $\bar{n}$ indicates the average number of X-ray photons absorbed per unit area. When $WS\ (u)$ is taken to be granularity, $1/\bar{n}$. to be sensitivity, $(\log_{10}e)\ G$ to be contrast, and MTF(u) to be sharpness, it can be expressed as

$$\text{Granularity} = \text{sensitivity} \times \text{contrast}^2 \times \text{sharpness}^2 \quad (4)$$

Therefore, the DR X-ray imaging dose can be estimated from noise characteristics by treating the number of incident photons as an index that corresponds to the sensitivity of the S/F system.

2. Experimental Methods

2-1 Experiment plan and sample preparation

The experiment plan for WS measurement according to radiation quality[8] standards established by the Bureau of Radiological Health (BRH) and sample preparations for ROC analysis is shown in **Fig. 1**. The X-ray generator used was a KXO-80G (Toshiba Medical Systems Corporation) and the CR used was a Re-

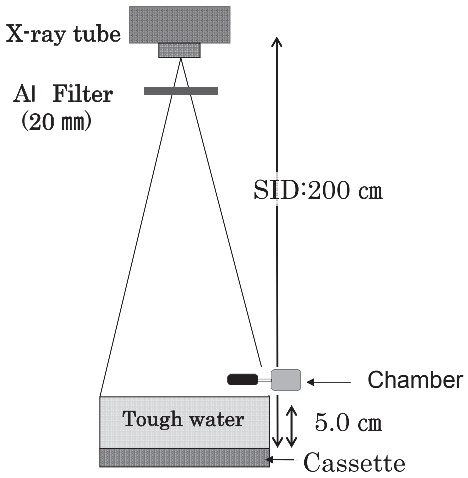


Fig. 1 Experimental layout of noise measurements using tough water.

gius Model 170 (Konica Minolta Inc.). The distance (source-to-image distance: SID) between the focus and the stimulable phosphor plate (hereinafter referred to as plate) was 200 cm. Tough water manufactured by Kyoto Kagaku Co., Ltd. was used as a scattering body (350 × 350 × 50 mm) and was set above the plate, and the measurement samples were imaged. Digital imaging and communication in medicine (DICOM) specification output images were output as straight line gradients without frequency processing or other types of processing.

The standard dose was determined using an SRO 250/SRG (Konica Minolta Inc.) fitted with a 20.0 mm Al filter on the X-ray tube side on the S/F system sensitive material. It was the surface dose (air kerma) for an X-ray tube voltage of 80 kV, an X-ray tube current of 100 mA, and an imaging time of 0.140 s obtained for a film density of 1.0 ± 0.05 as measured by a diffusion densitometer (Konica Minolta Inc.).

We obtained an average value of 23 μGy (0.69μC/kg) from 5 irradiations of the incident dose on the surface of the tough water as measured using the NERO™ mAx Model 8000 (VICTOREEN). This surface dose was used as the standard (criterion) imaging dose. The automatic developer used was the Konica Minolta SRX-503, the development processing time was 90 s, and the development temperature was 33.5 °C.

Using the criterion dose as a reference point, we created five samples with imaging times of approximately 1/4 (6 μGy), 1/2 (12 μGy), 1 (23 μGy), 2-fold (47 μGy), and 4-fold (95 μGy). Doses were the average of these five. Two types of samples were used: those with a standard pixel size (ST: 0.175 mm) and those with a high-quality pixel size (HQ: 0.0875 mm). We created five images for each of the pixel sizes and for each of the samples by using the same imaging conditions. This yielded a total of 50 DICOM image samples with noise measurements.

2-2 Measurements of noise characteristics

2-2-1 Measurements of RMS granularity

Noise measurements (DICOM images) were conducted using the free image processing software Image J. The calculation range of RMS granularity we used set the region at the center of the display screen that was 256 × 256 pixels as the region of interest (ROI). The 50 ST and HQ images in this range were calculated using Image J to derive RMS granularity. The RMS calculation formula we used is shown below:

$$RMS = \sqrt{\frac{1}{\mathrm{n}}\sum_{i=1}^{n}\sum_{j=1}^{n}(PV_{i,j} - \overline{\mathrm{PV}})^2} \quad (5)$$

In this formula, n is the number of data items, PV_{ij} is the pixel value, and, $\overline{PV}$ is average pixel value.

2-2-2 WS measurements

WS measurements were conducted using two-dimensional fast Fourier transformations (hereinafter referred to as 2DFFT)[9] which were in accordance with International Electrotechnical Commission (IEC) standards, on uniformly irradiated DICOM images. We set the calculation range of 2DFFT to one segment (hereinafter referred to as SEG) of the 256 × 256 pixel image within the ROI. Trend correction for this region was set to calculate two-dimensional quadratic-approximation images according to the Legendre polynomial and corrected for the amount subtracted from the original image. The input/output characteristics of these images, which are indicated in the formula below, were then calculated in the log system (CR) using 2DFFT.

$$WS_{\frac{\Delta E}{E}}(u_j, v_k) = \frac{1}{G^2(\log_{10} e)^2} \frac{\Delta x \Delta y}{N_x N_y} \frac{1}{M} \sum_{m=1}^{M} \left| DFT^{2D} \{ \Delta PV_m(x_s, y_t) \} \right|^2 \quad (6)$$

In this formula, $\Delta_x \Delta_y$ indicates pixel size, $N_x N_y$ is the number of data items set within the ROI, M is the number of segments, DFT^{2D} is the two-dimensional discrete Fourier transform, and ΔPV is the variation component of the pixel values.

WS values used in our assessment were the average of 64 SEG for each sample, with a total of 320 SEG from five samples additionally averaged. Frequency bins were calculated using 14 sequences (excluding those above the axis of WS spatial frequency [u, v] on the two-dimensional distribution), with bin width calculated at approximately 0.114 cycle/mm for ST and at approximately 0.229 cycle/mm for HQ. Digital $WS_{\Delta E/E}$ in formula (6) was calculated by linearizing the exposure conversion using $G^2 \cdot (\log_{10} e)^2$ in the denominator on the right side of the equation in the exposure conversion and calculating the dimension of the X-ray quantum. Thus, *NEQ (u)* and *DQE (u)* for the digital system were calculated in formulas (1) and (2) with the conversion coefficient $(\log_{10} e)^2 \cdot G^2$ in the numerator on the right side of the equation removed.

2-3 Estimation of imaging dose using WS

It has been reported that the noise characteristics in the S/F system correspond to the WS value of the 0.1–0.5 cycles/mm low spatial frequency range in terms of visual assessment[8,10]. Thus, we estimated the threshold for the optimization of the imaging dose from the average WS value at the minimum spatial frequency, which is determined by the reciprocal of the product of the number of data items and pixel size, and the imaging dose.

2-4 Creation of samples and observation method for ROC analysis

2-4-1 Creation of samples for ROC analysis

Samples for use in ROC analysis were created in the same way as the WS samples. A single sheet of film was divided into 30 parts by punching 30 holes in a 20 × 35 [mm] grid pattern on a copper plate measuring 254 × 305 [mm] and 0.1 [mm] thick[7)]. Acrylic beads ϕ 2.0 mm were placed randomly in 15 of the 30 holes. Data from 15 beads with signals and 15 beads without signals for each sheet of film were then collected.

ST and HQ observation samples for the S/F system and CR totaled 120 data items for 60 beads with signals and 60 beads without signals. The placement of the beads was then changed for each of the 4 sheets of film for a total of 12 sheets of film providing data. The standard SRO250/SRG was used to obtain data from the S/F system. Hardcopy (film) CR images used for ROC analysis were processed as follows. The DICOM standard default window width (2047) and window level (4096) pixel values were selected on the Regius Model 170, and the linear gradient of LIN-01 was selected from the lookup table without performing frequency processing. A film density of 1.00 ± 0.05 was output for all actual size ST (0.175 mm) and HQ (0.0875 mm) images by using the dry imager DRY-PRO 752 (Konica Minolta Inc.).

2-4-2 Observation experiment for ROC analysis

Observations were carried out by six students who had been trained to read observation samples.

Regarding the data obtained from the experiment, rules have been established for publishing the results and using the results as a resource for educational material, and the consent of the observers have been obtained.

As points of note prior to the actual observation, we requested the observers that when viewing from the direct viewing angle, they should not compare the hole under observation with any of the other 29 holes in the sample, and especially not the 8 to the top, bottom, left, and right in the immediate vicinity of the hole under observation. The observation distance and duration were freely determined by the observers themselves. They observed the samples in order without any particular restrictions. Considering the influence of the learning curve effect, we presented the samples in a different order for each observer and took into consideration the order effect. Ratings for certainty were given using the continuous certainty factor method with 50 points set as the maximum.

Film images were read in the following environment: viewing screen was placed so that it would not be influenced by outside light. We measured the light in a room with normally used lighting by using a luminance meter (Konica Minolta Inc., LS-100), and obtained an approximate value of 57 cd/m^2. The brightness of the viewing screen (Moriyama, for X-ray use: CH5K) front panel was measured to be approximately 2,600 cd/m^2.

2-4-3 Rating AUC average values

Rating of the average values for the detection ability of ROC analysis (AUC) was performed as follows. Standard deviation was calculated from the variance between the observers using the paired t-test on both sides to determine the difference in the average values. Then, we used the Jackknife method to assess the standard deviation of the estimator because this method removes the influence of variance that occurs between observers and between samples from overall error variance.

Jackknife rating was performed with LABMRMC[11] (DBM method: D.D. Dorfman, K Berbaum, University of Iowa, C.E. Metz, University of Chicago) using the continuous certainty factor method. Rating results according to the analysis of variance performed using the DBM method included the following variance components: inter-system (T), inter-observer (R), inter-sample (C), system-observer (TR), system-sample (TC), observer-sample (RC), system-observer-sample (TRC), and total (Total).

Two-tailed paired t-tests were used to rate the statistically significant difference between two groups (S/F system and ST or HQ, and ST and HQ), in order to ensure that redundancy did not affect the results.

3. Measurement results

3-1 RMS granularity and imaging dose

We calculated RMS for the approximately 6,600 pixels set as the ROI of the 256 × 256 pixel images for each sample. The average RMS value for the approximately 33,000 pixels of the five samples was obtained using RMS calculations. The results are shown in Fig. 2. The RMS value for ST and HQ images sharply decreased as dose increased in the low-dose region, but gradual decreases were observed at high doses near the criterion dose of 23 μGy.

3-2 WS and imaging dose

Fig. 3 and 4 show the results for the horizontal (scan) and vertical WS calculated for a total of 320 SEG from both ST and HQ images

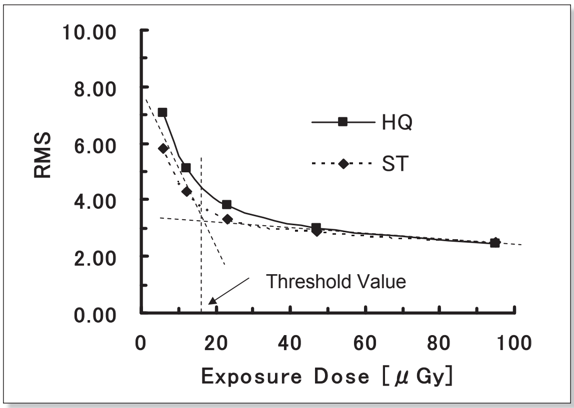


Fig. 2 Relationship between the root mean square (RMS) and exposure dose using Regius 170.

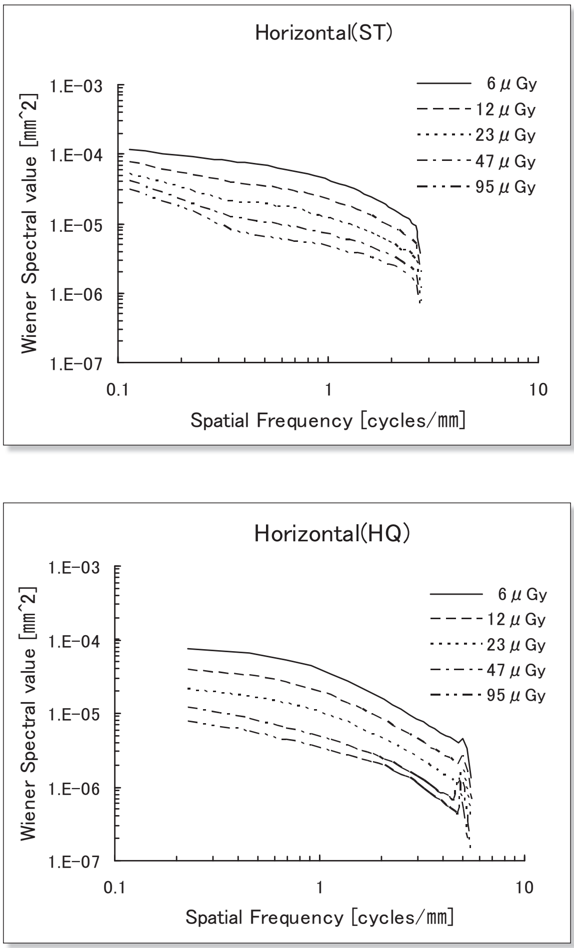


Fig. 3 Result of horizontal Wiener spectrum calculated by two dimension fast Fourier transform method by Regius 170.
a/b (a) standard (ST), (b) high quality (HQ)

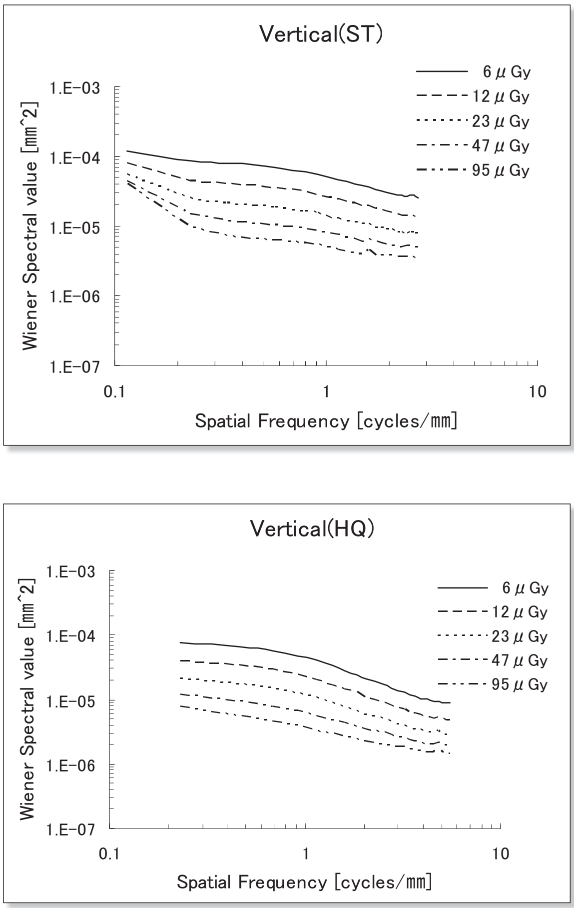


Fig. 4 Result of vertical Wiener spectrum calculated by two dimension fast Fourier transform method by Regius 170.
a/b (a) standard (ST), (b) high quality (HQ)

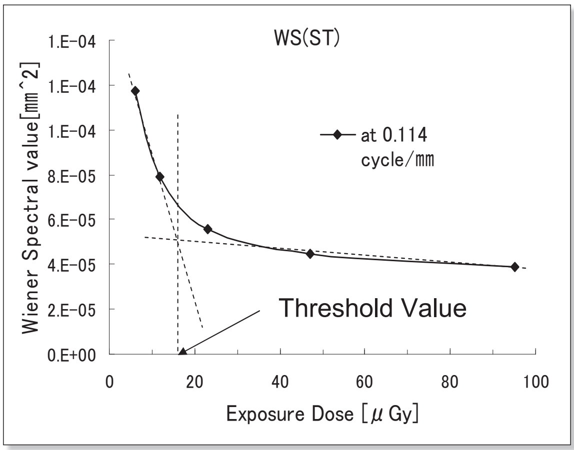
using the 2DFFT method. Since the WS values were linearized according to the frequency bins and each sample was indicated as an average of its 64 SEG, variance in all spatial frequency regions was small and gradual.

Horizontal and vertical WS values for the minimum spatial frequency regions were equivalent. In high-frequency regions, horizontal WS values tended to be slightly lower owing to the CR property for sharpness to decrease because of the fact that it scans data using laser light. Moreover, horizontal HQ spiked when in the vicinity of the Nyquist frequency, possibly owing to the low-pass filter.

The relationship between WS values in the low-spatial-frequency region (ST: 0.114 cycle/mm, HQ: 0.229 cycles/mm) and imaging dose is shown in **Fig. 5**. WS values increased as dose increased, as was seen with RMS values, but gradual decreases were observed at doses higher than the criterion dose of 23 μGy.

3-3 ROC analysis and AUC

A comparison of ROC curves for samples imaged at the criterion dose of 23 μGy using the S/F system SRO250/SRG and the CR ST and HQ is shown in **Fig. 6**. Our rating of the statistically significant difference between the systems using the paired t-test on both sides and the Jackknife method indicated that there were no significant differences. No significant differences were observed for any of the variance items in the Jackknife analysis-of-variance table for ST and HQ images of CR (**Table**



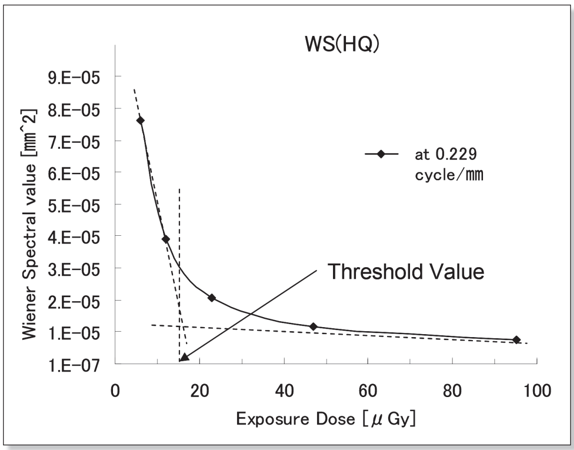


Fig. 5 a/b Relationship between the Wiener spectrum and exposure dose using Regius 170. (a) standard (ST), (b) high quality (HQ)

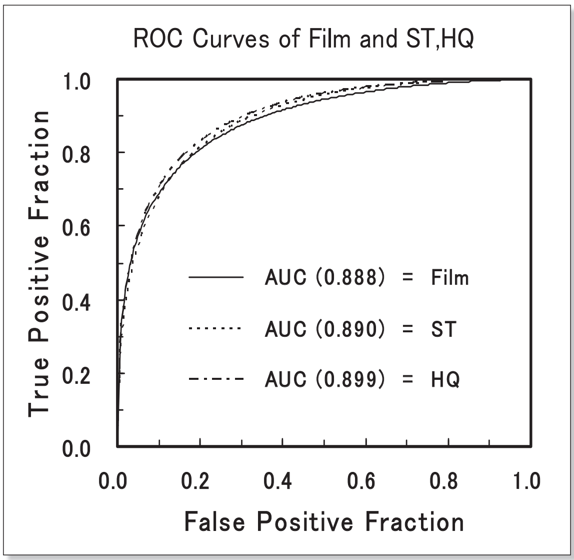


Fig. 6 Comparison of ROC analysis by screen-film systems and computed radiography for the same dose.

1).

In the analysis-of-variance table, the degree of freedom used to calculate the F-distribution ratio was derived by calculating (c - 1) and (r - 1). The asterisk (*) indicates corrections made to the degree of freedom by using the Satterthwaite approximation for denominator synthesis.

$$df(2) = \frac{(MS_{TR} + MS_{TC} + MS_{TRC})^2}{\frac{MS^2{}_{TR}}{(r-1)} + \frac{MS^2{}_{TC}}{(c-1)} + \frac{MS^2{}_{TCR}}{(r-1)(c-1)}} \tag{7}$$

In this formula, MS_{TR} is the modality-observer variance component, MS_{TC} is the observer-sample variance component, MS_{TRC} is the modality-observer-sample variance component, C is the number of samples, and r is the number of observers. The double asterisk (**) indicates that rating was not performed for observer-sample (RC) when the sample dispersion was large.

4. Discussion

The present study investigated the relationship between imaging dose and noise characteristics as well as a simple method for determining imaging conditions for optimal CR imaging dose.

Noise characteristics were indicated by RMS and WS measurements. Aoki *et al*[12] integrated WS (u) in the spatial frequency region and calculated RMS granularity from its square root. They reported that their comparison of this RMS granularity with graininess assessed using the paired comparison method indicated that there was good correlation at relatively low spatial frequency regions around the spatial frequency of 1.0 cycle/mm. The BRH report[8] indicated that since there was good correspondence to visual assessments, granularity characteristics in the S/F system are indicated by WS values at 0.1 cycle/mm.

RMS values calculated for standard dose DICOM images using Image J were 3.31 for ST

Table 1 Statistically significant (SIG) testing of AUC value using the Two tailed paired t-test and Jackknife method for Screen-Film system and computed radiography in standard dose.

Combination (Modality)	Jackknife method							paired t-test
	Source	Source Sums of Squares	Degree of freedom	Mean Squares	F Ratios	Prob	Decision	p value
Film and ST	TOT	228.0506	1439				SIG.	0.2774
	T	0.0646	1	0.0646	*	*		
	C	20.424	119	0.1716	1.0513	0.35		
	R	1.4345	5	0.2869	1.7573	0.1197		
	TC	21.7887	119	0.1831	1.2679	0.0405		
	TR	1.2715	5	0.2543	1.7609	0.1189		
	RC	97.1407	595	0.1633	**	**		
	TRC	85.9267	595	0.1444				
Film and HQ	TOT	241.1264	1439					0.5781
	T	0.0146	1	0.0146	*	*		
	C	22.4566	119	0.1887	1.192	0.0984		
	R	1.1185	5	0.2237	1.4129	0.2176		
	TC	22.5742	119	0.1897	1.1347	0.1753		
	TR	1.2931	5	0.2586	1.547	0.1733		
	RC	94.2005	595	0.1583	**	**		
	TRC	99.4689	595	0.1672				
ST and HQ	TOT	228.3223	1439					0.4450
	T	0.0178	1	0.0178	0.0974	0.7556		
	C	21.0527	119	0.1769	1.1163	0.2075		
	R	0.8897	5	0.1779	1.1227	0.347		
	TC	21.7308	119	0.1826	1.2099	0.0807		
	TR	0.5273	5	0.1055	0.6988	0.6245		
	RC	94.2972	595	0.1585	**	**		
	TRC	89.8068	595	0.1509				

Film with SRO250/SRG System

and 3.79 for HQ. We calculated the area of the vertical WS (u) spatial frequency region, in which sharpness is not affected by laser scanning, using the trapezoidal rule and the Simpson's rule. The RMS granularity obtained by the square root of that value were similar for both methods, at 3.24 for ST and 3.62 for HQ. We believe this was due to the fact that no integral error occurred in either method since the WS (u) spectral variation was small. RMS values obtained when WS (u) was integrated were slightly lower. We assume this difference was due to the fact that the WS (u) integration range was limited. Thus, in the present study, RMS and WS can both be used to evaluate noise characteristics.

RMS values and WS values for ST and HQ improved as imaging dose increased (Fig. 2, 5). We believe this was due to improvements in granularity caused by the fact that quantum mottle is in inverse proportion to imaging dose, which led to improved noise. However, we observed gradual decreases (improvement) at doses higher than the criterion dose of 23 μ Gy. We believe that this was due to the fact that while quantum noise is predominant in the low dose range, system noise becomes more prominent in the high dose range as the dose increases.

It has been previously pointed out that DR imaging doses are higher in comparison to S/F system imaging doses[2]. Ogawa *et al*[13]. compared WS values in the standard S/F system and CR using an indirect FPD that calculated overall WS. Their results indicated that since doses with the same WS value as the S/F system are 1.3 to 1.5 fold in CR and 1.3 fold in FPD, in actual clinical practice, they are set at approximately 1.3 fold the CR and FPD imaging conditions in the S/F system. This result is in accordance with the ICRP report[2] that points out the increased exposure used in DR imaging. However, since doses that are the same as those used in the S/F system are estimated[7] to be in the region in which system noise is predominant, we believe they play no role in the improved detection ability of visual assessment.

In general, DR imaging is performed under the same imaging conditions as the S/F system. In the present study, when the dose obtained at a density of 1.0 ± 0.05 in the S/F system was used as the BRH radiation quality standard, the imaging dose was approximately 23 μGy. At this dose, the results of ROC analysis of S/F system and hard copy (film) images of ST and HQ of CR made using the signals of ϕ 2.0 mm acrylic beads indicated that the AUC for detection ability resembled a curve when at nearly the same value, that there was no statistically significant difference in rating, and that standard S/F system images and CR images were equivalent (Fig. 6, Table 1).

The authors determined that the threshold[7] that does not contribute to improvement in image quality even when the exposure is increased was at the border between the high dose region in which system noise is predominant and the low dose region in which quantum noise is predominant, and that the optimum imaging dose is this threshold value that takes into consideration a balance between dose and image quality. The AUC for ST and HQ hard copy images that was performed concurrently showed no statistically significant differences with the S/F system standard doses even at 1/2 dose. When one considers that this 50% value is near the border of detectability, it is possible to consider that the 30% lower threshold estimated using IQF is the imaging dose that can be efficiently judged as the balance between noise characteristics and image quality, which are dependent upon the dose. As a result, unlike previous physical assessment reports, detectability in visual assessments also indicates that the dose can be reduced by 30% lower than the S/F system imaging dose that was set to be the standard.

In the present study, we determined from the relationship between the RMS and WS values to the imaging dose that the point of intersection in linear approximation of the low exposure region that is influenced by quantum mottle and the high exposure region that is dependent upon system noise was 17 μGy. By defining this point of intersection as the threshold value of the optimization of imaging dose, we calculated 26% from 17 (μGy)/23 (μGy), which was nearly the same result as the 30% we calculated using IQF[7]. Consequently, the threshold estimated from RMS and WS values and imaging dose can reduce imaging dose by 30%, which suggests that it can be used as a parameter for the optimization of imaging dose.

IQF and AUC signal data obtained using Burger phantoms and acrylic beads were in a low spatial frequency region[8, 10] with a high degree of correlation with visual characteristics due to the phantom diameter. DQE (u), which is used to assess digital systems, is not affected by contrast and spatial frequency characteristics because it is determined by the ratio of fluctuation between the average number of X-ray photons ($\overline{n}$) absorbed per unit area when using CR and FPD devices and the number of incident photons (q: dose). Thus, we were able to logically verify that the CR X-ray imaging conditions based on film output (hard copy) standards can allow the radiation dose to be lowered to around 70% of the imaging conditions used in the S/F system by using the threshold that is estimated from RMS values, WS values for the low spatial frequency region, and imaging dose.

Our investigation of the relationship between noise characteristics and imaging dose in CR and our measurements of RMS and WS noise allowed us to simply create samples and perform analysis and estimate imaging dose with equal capacity, in comparison to IQF and AUC that are visual assessment methods. The fact that we were able to simply calculate RMS values using the free image processing software Image J is a particular advantage of our method. In the future, we would like to investigate the usefulness of optimizing imaging dose via our method using human equivalent phantoms and establish that our method is a simple way of determining clinically practical X-ray imaging dose conditions that is in accordance with the Medical Exposure Guidelines 2006[14] that are recommended by this journal.

5. Conclusions

Since systematic and appropriate exposure guidelines for DR imaging have not yet been established, it is difficult to set the proper imaging conditions. In the present study, we used CR to investigate the optimization of X-ray imaging performed using WS values and imaging dose, which wre well matched to visual assessments. Our results suggested that in these fundamental experiments CR imaging dose can be lowered to about 70% of the radiation dose based on the ratio between the standard imaging dose in the S/F system and the WS value of CR. We also obtained a similar result from the relationship between RMS value and imaging dose. Noise measurements using RMS and WS were easier to test and analyze than the visual assessment method of IQF and AUC, which indicates that our method is useful as a systematic method of determining X-ray imaging conditions for digital images.

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Actual Conditions of Intervention by Radiological Technologists in the Form of Querying Doubtful Points in Examining Request Slips from Physicians and Dentists

Yasuo Nakazawa[1) 5)] **Masaru Nitta**[2)] **Chikara Noda**[3)]
Junya Nakashima[4)] **Hisaya Sato**[1) 3)] **Kyoichi Kato**[1) 4)]

1) Showa University Graduate School of Nursing and Rehabilitation Sciences
2) Department of Radiology, Showa University Northern Yokohama Hospital
3) Department of Radiology, Showa University Hospital
4) Department of Radiology, Showa University Fujigaoka Hospital
5) Department of Radiology, Showa University

Key words: Examination of request slips, querying activities, role of radiological technologists, ensuring medical safety, ensuring the efficacy of examinations and treatment

【Abstract】

We conducted a national survey of the actual conditions of intervention by radiological technologists to examine request slips from physicians and dentists and query doubtful points as a safety measure in radiological examinations and treatment. As a result, it was found that radiological technologists do perform the activities of examining request slips from physicians and dentists to query points that are unclear or in doubt in many facilities. At the same time, it was learned that these activities are not reviewed or recorded as queries. On the other hand, it was clearly shown that since the role that radiological technologists play by querying doubtful points can prevent the wrong examination or treatment from being performed or administered, this intervention contributes to ensuring medical safety and the efficacy of examinations and therapy. These results were suggested that queries by radiological technologists are necessary and important activities from the standpoint of ensuring medical safety.

Introduction

On January 11, 1999, a medical accident occurred in a university hospital, in which a patient scheduled to undergo a heart surgery was mixed up with another patient scheduled to undergo a lung surgery. The mistake was not noticed until the patients were transferred to the intensive care unit (ICU) after the surgeries, which subsequently led to a serious social problem[1) 2)]. Owing to this medical accident, a paternalistic social community of medical care gradually transformed into patient-centered team medicine, in which patients are considered as partners[3)]. Subsequently, in the Medical Safety Measure Conference conducted in April 2002, the Ministry of Health, Labor and Welfare prescribed "Comprehensive Measures for the Promotion of Medical Safety," and requested all hospitals and clinics with beds to have clear safety management guidelines, in-hospital systems to report accidents and other such events, a safety management committee, and implement staff training for safety management[4)]. These guidelines required all parties concerned, including the government, to make aggressive efforts to enhance the safety and reliability of medical care, because medical safety measures had not been important issues in medical policy.

Moreover, in order to secure medical safety and provide anxiety-free and safe medical care, an institution was constituted in October 2004 to ensure that national and university hospitals that offer advanced treatment report medical accidents[5]. Such incidents are to be reported to the Center for Medical Accident Prevention, Japan Council for Quality Health Care. The council currently has 1,373 medical facilities as members (March 2014). As a neutral third party organization, the Center for Medical Accident Prevention assembles the information related to medical accidents and other such incidents, and presents the tabulation/analysis results as a report. This report is available to all stakeholders in the society, including medical facilities, citizens, and administrative organizations, to promote information sharing. In addition, the Ministry of Health, Labor and Welfare has enforced the revised Medical Service Law since April 2007, making it mandatory to have a medical safety management system, drug safety management system, management system for prevention of infections, and medical equipment safety management system.

Although the condition of medical safety has developed as discussed above, the actual condition of examination of requests for radiologic examination/therapy by physicians/dentists working in hospitals and clinics, in radiological technologists' service, and clarification of doubts related to the same, is unclear. Therefore, as a first step in this direction, we conducted a nationwide questionnaire survey of hospitals/clinics on querying doubtful points by radiological technologists regarding the radiologic examination/therapy requests issued by physicians/dentists. This was done by examining "Factual Survey of Utilization of Medication History and Actual Conditions of Prescription Queries[6]" report published by the Japan Pharmaceutical Association, Prescription Queries of Pharmacists[7], and Prescription Queries Q&A for Patients[8].

1. Methods

1-1. Definition of terms

No studies have been conducted on the actual condition of examination of request slips or clarification of doubts related to the same, with reference to radiological technologists' services, since the establishment of the Act on Medical Radiology Technicians in 1951. Therefore, to help the participating radiological technologists answer the items in the questionnaire by ensuring a common understanding of the terms, we defined "request slip", "examination of a request slip", "querying doubtful points", and "change/addition/deletion of examination/treatment" by referring to the "Factual Survey of Utilization of Medication History and Actual Conditions of Prescription Queries[6]", Prescription Queries of Pharmacists[7], and Prescription Queries Q&A for Patients[8] reports.

A "request slip" refers to a slip in which specific instructions have been provided by a physician or dentist, regarding the exposure of the human body to radiation (regardless of whether it is on paper or in an electronic form).

A "Examination of a request slip" refers to the confirmation by a radiological technologist as to whether a request slip prepared by a physician or dentist to conduct imaging examination or radiation therapy (examination/treatment hereinafter) is appropriate regarding the following items (excluding the examination of the purpose of examination/treatment): the side, method, range, position, equipment/auxiliary tools, interactions, duplication, frequency (too many/too less), burden on human body(radiation exposure/labor), contrast medium, drug allergy, adverse drug reactions, pregnant/lactating women, etc. With reference to interactions, the purpose of the examination is to collect information on doubtful points that may arise due to the interaction in the same examination/treatment, as well as between the examination and other examination/treatment, food and drink, etc., querying doubtful points arising from the examination order of upper gastrointestinal radiologic examination and abdominal plain radiography, interference between thyroid gland examination and examination using iodine contrast medium in the nuclear scanning, and food and drink before examination.

A "querying doubtful points" refers to the asking for clarification of the "doubtful point," if any, in a request slip prepared by the radiological technologist, addressed to the physician/dentist who prepared the original request slip.

A "Change/addition/deletion of examination/treatment" refers to change, addition, or deletion of the instruction details as a result of the clarification of a "doubtful point" by a radiological technologist, through inquiry with the physician/dentist, after examination of a request slip (irrespective of who made the change, addition, and deletion).

1-2. Survey method

In total, 1,129 facilities participated in this nationwide questionnaire survey, including hospitals/clinics selected randomly. The survey period was from December 1, 2012 to February 14, 2013. The self-administered questionnaire was mailed to the participants, and completed questionnaires were received by mail.

1-3. Details of the questionnaire

The questionnaire comprised three parts. Part 1 included definition of the terms, Part 2 included items related to general points regarding the hospital, and Part 3 was the factual survey on the examination and querying of doubtful points on request slips. The major contents have been presented below:

1) Status of the examination and querying of doubtful points on request slips.
2) Status of statistical collection, review, and recording of the examination and querying doubtful points on request slips.
3) Trends in querying doubtful points.
4) Whether near-miss events are reported as medical safety cases.
5) Detailed contributions of the radiological technologist through querying doubtful points.

1-4. Ethical considerations

Before implementation of this questionnaire survey, the Graduate School of Nursing and Rehabilitation Sciences adjudged that the survey would require no approval by the ethics review board. The institutional data obtained from this questionnaire were used only in this survey. In addition, the identity of the facilities has been protected while expressing the results.

2. Results

2-1. Response rate

In all, 647 facilities responded, including 81 governmental facilities (governed by the Ministry of Health, Labor and Welfare, National Hospital Organization, Japan Labor Health and Welfare Organization, etc.), 137 public facilities (prefectures, municipalities, a part of partnerships, etc.), 72 communal facilities (e.g., Japan Red Cross, Social Welfare Organization Saiseikai Imperial Gift Foundation, Hokkaido Shakaijigyo, Kouseiren, etc.), 22 social insurance-associated groups (e.g., All Japan Federation of Social Insurance Associations, Employees' Pension Welfare Corporation, Shipmen's Social Insurance Society, Health Insurance Societies, etc.), 275 medical corporations, and 60 other facilities. The overall response rate was 57.3%. In terms of the number of radiological technologists belonging to those facilities, we found that most of the facilities, specifically, 358 facilities had 1 to 9 technologists, followed by 130 facilities that had 10 to 19 technologists, and 74 facilities had 20 to 29 technologists.

2-2. Response to questions

2-2-1. Status of examinations and querying of doubtful points on request slips

The answers "Radiological technologists examine request slips and query points that are unclear or in doubt", "Radiological technologists neither examine request slips nor query points that are unclear or in doubt", and "Radiological technologists do not examine request slips" accounted for 85.5% (550 facilities), 5.1% (33 facilities), and 4.4% of the responses, respectively (Fig. 1). The category "Others" included responses such as, "the radiological technologist performs examinations/querying of doubtful points only when related to general radiography", "we have no clear system", "these are only performed personally and no efforts are made by our organization", and "the receptionist in charge of reservation performs the prescription queries".

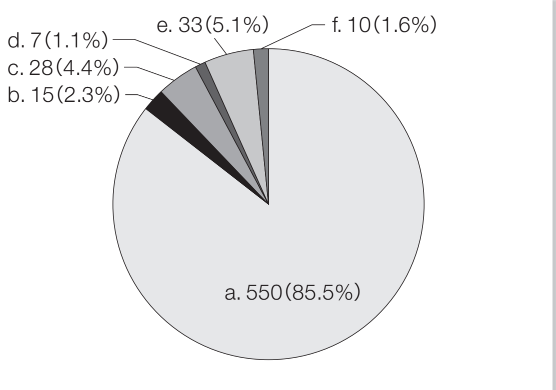


Fig.1 Do radiological technologists examine request slips and query points that are unclear or in doubt?
Valid response: 643 facilities (57.0%)

a. Radiological technologists examine request slips and query points that are unclear or in doubt.
b. Radiological technologists examine request slips but do not query points that are unclear or in doubt.
c. Radiological technologists do not examine request slips.
d. Radiological technologists do not query points that are unclear or in doubt.
e. Radiological technologists neither examine request slips nor query points that are unclear or in doubt.
f. Other

2-2-2. Status of statistical collection, review, and recording of examinations and querying of doubtful points on request slips

The answers "the radiological technologist examines request slips and the review and record statistics of prescription queries by considering any doubtful points" and "the radiological technologist does not perform this" accounted for 5.4% (31 facilities) and 94.6% (539 facilities) of the responses, respectively (Fig. 2). Querying doubtful points were 963 queries

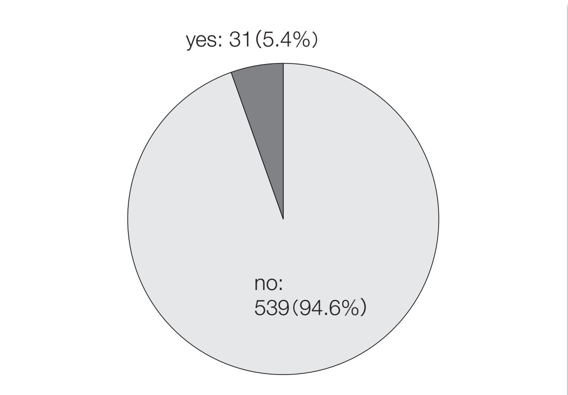


Fig.2 Do radiological technologists survey and record statistics on queries made regarding "doubtful points" discovered by radiological technologists who have examined request slips?
Valid response: 570 facilities (50.5%)

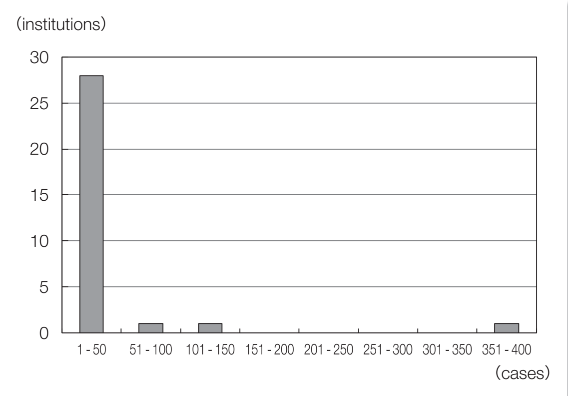


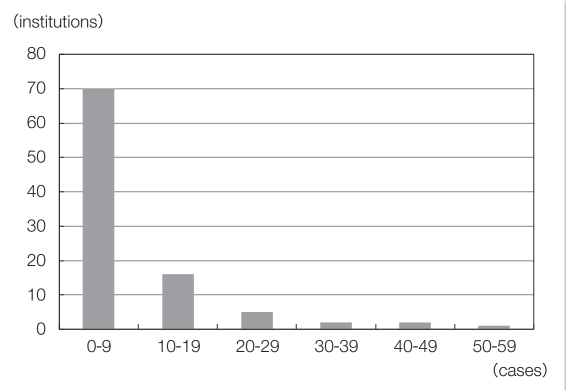
Fig.3 Number of queries made on doubtful points per month.
* Pertains to the 31 facilities that survey and record statistics
Valid response: 31 facilities

Total number of queries: 963 (queries/month)
Mean value: 31.1 (queries/month)
Median value: 10 (queries/month)

Table 1 Number of cases per month in which the instructions are changed, added, or eliminated as a result of queries.

* Pertains to the 31 facilities that survey and record statistics

Content of change, addition, elimination	Total number of queries	Number of queries	Percentage (%)
[1] Side examined/treated (left/right/upper/lower/both, etc.)	573	257	44.9
[2] Method of examination/treatment		26	4.5
[3] Site of examination/treatment		90	15.7
[4] Scope of examination/treatment		18	3.1
[5] Position of examination/treatment		54	9.4
[6] Examination/treatment devices and tools		38	6.6
[7] Examination/treatment interactions		12	2.1
[8] Redundancy of examination/treatment		14	2.4
[9] Number of examinations/treatments (too many/too few)		9	1.6
[10] Burden of examinations/treatments (vocalization, respiration, weighting, position, drugs, other)		3	0.5
[11] Contrast medium		28	4.9
[12] From drug allergies		2	0.3
[13] From adverse effect or suspicion thereof.		14	2.4
[14] Pregnant/nursing women		2	0.3
[15] Others (safety confirmation in MRI, violation of rule, patient ID)		6	1.0



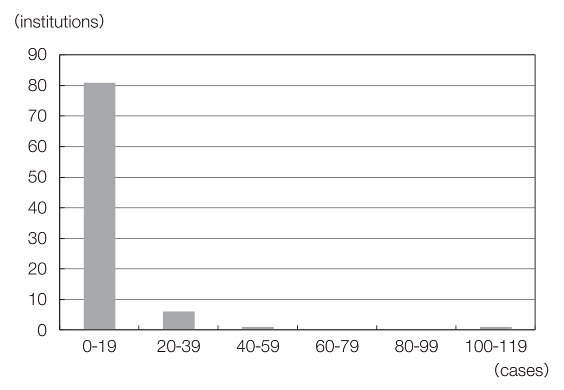


Fig. 4 Hypothetical effect as if this had been performed as before the change.

(a) Number of queries where an assumption has been made that the patient's physician/dentist might damage his/her health.
Valid response: 96 facilities

Total number of queries: 651 (queries/month)
Mean value: 6.8 (queries/month)
Median value: 3 (queries/month)

(b) Number of queries where an assumption has been made that the result intended by the physician or dentist was not obtained.
Valid response: 89 facilities

Total number of queries: 543 (queries/month)
Mean value: 6.1 (queries/month)
Median value: 2.3 (queries/month)

per month in the 31 facilities. An average was 31.1 queries per facilities (Fig. 3). The number of queries in which the instructions were changed, added, or deleted as a result of prescription queries was the highest for the examination/treatment side (44.9%, 257 queries), followed by 15.7% (90 queries) for the examination/treatment site, and 9.4% (54 queries) for examination/treatment position (Table 1). The monthly number of queries in which a health hazard for the patient (exposure to unnecessary radiation, unnecessary drug administration, etc.) was speculated to have occurred if the examination/treatment was conducted according to the instruction before the change was 651 in 96 facilities, with an average of about 6.8 queries per facilities (Fig. 4a). In addition, the monthly number of queries in which it was speculated that the physician's/dentist's intended result would not have been obtained was 543 in 89 facilities, with an average of about 6.1 queries per facilities (Fig. 4b).

2-2-3. Inclination to query doubtful points

Analysis of the trends leading to a query of doubtful points revealed that most participants responded “prescription queries tend to go to specific persons among those who issue request slips”, 246 facilities, followed by “prescription queries tend to go to specific departments”, 222 facilities (Fig. 5). The category “Others” included responses such as “there are more prescription queries when physicians request for something that is not their specialty”, “copy and paste is frequently used due to the electronic medical record system”, “the request slips are illegible”, and “conversation with the patient leads to a query of doubtful points in some queries”.

2-2-4. Whether near-miss events are reported as medical safety issues

“Near-miss events are reported as medical safety issues, to an appropriate institutional section” accounted for 80.2% (465 facilities) of the responses, whereas “not reported” accounted for 19.8% (115 facilities) (Fig. 6).

2-2-5. Detailed contributions of radiological technologists through prescription queries

When looking at the contributions of radiological technologists through prescription queries, the response “I successfully prevented a wrong examination/treatment” was most often cited (536 facilities), followed by “I successfully ensured safety” (403 facilities), and “I successfully secured efficacy of the examination/treatment” (377 facilities) (Fig. 7). The category “Others” included responses such as “I could contribute to construction of a confidential relationship with patients and other professionals such as physicians and nurses”, “I could develop trust in the hospital/medical facilities”, “a radiogram interpretation helps effective radiography”, “safety of medical practices has improved”, “I could reduce a sense

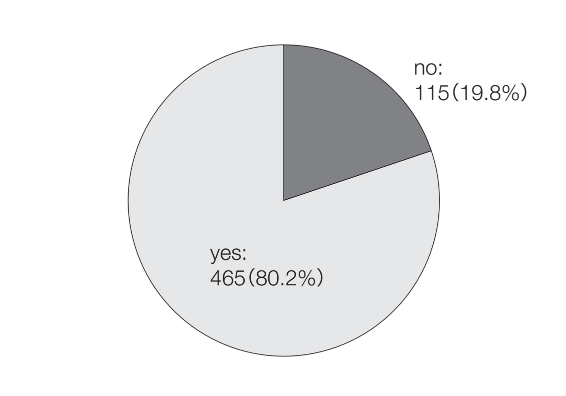


Fig. 6 Are “near misses” and other cases involving medical safety issues reported to the appropriate department of the facility?
Valid response: 580 facilities (51.4%)

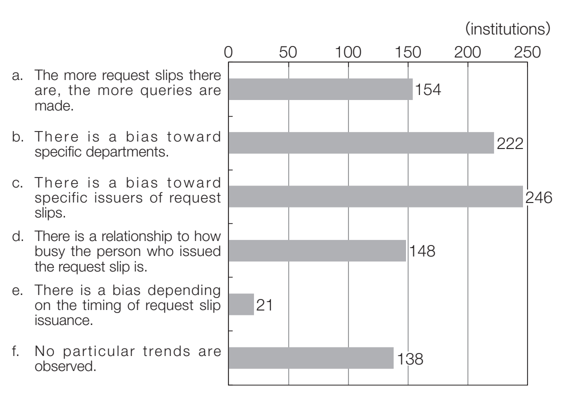


Fig. 5 Inclination to query doubtful points.
Valid response: 647 facilities (57.3%) (multiple choices allowed)

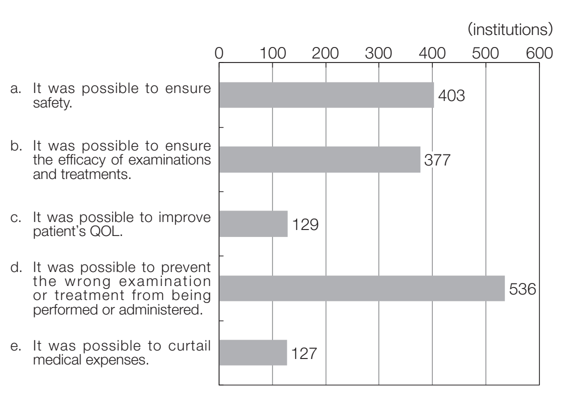


Fig. 7 Contribution made by the intervention of radiological technologists who query doubtful points.
Valid response: 647 facilities (57.3%) (multiple choices allowed)

of uneasiness in the patients", and "I could perform the required examination without delay".

3. Discussion

3-1. Querying doubtful points as an examination procedure

Radiological technologists perform absolute medical practices, as prescribed in the Medical Practitioners' Act. The Article 17 states, "One may not perform medical practices unless being a medical practitioner." Therefore, the request slips received from physicians/dentists, for radiologic examination/treatment, should be confirmed as an absolute examination procedure. Such procedures in other medical professions include prescription queries by pharmacists. The Pharmacists Law, Article 24 stipulates, "When there is any doubtful point in a prescription, pharmacist may not prepare a medicine with this unless he/she confirms the doubtful point by inquiring with the physician, dentist, or veterinarian who has delivered the prescription". If absolute confirmation procedures by radiological technologists can be legally stipulated as in the Pharmacists Law, opinions such as "the radiological technologist performs examinations/prescription queries only when related to general radiography", "we have no clear system", "these are only performed personally and no efforts are made by our organization", "the receptionist in charge of reservation performs prescription queries" found in this questionnaire survey may be improved. We also consider that it can eliminate radiation exposure by unnecessary radiography that occurs due to absence of querying doubtful points.

3-2. Status of examinations and querying doubtful points on request slips

In 85.5% of the facilities that provided valid responses, radiological technologists performed examinations and querying doubtful points on request slips. However, it was revealed that 94.6% of the facilities do not review and record them as querying doubtful points. In addition, judging from the fact that examinations/querying doubtful points are done only for general radiography, and opinions such as "there is no clear system," facilities in which the radiology department makes efforts in examinations and querying doubtful points on request slips systematically may be very few in number. However, given the fact that 80.2% of the facilities report querying doubtful points as near-miss events to the appropriate institutional section, specialized sections such as medical safety office may be engaged in the recording/analysis. Radiological technologists perform absolute medical practices prescribed in the Medical Practitioners' Act, Article 17 as "One may not perform medical practices unless being medical practitioner". Therefore, the querying doubtful points procedure needs to be transformed into a routine procedure as a part of medical safety operations in radiology departments. In addition, a medical safety office supervising the facilities and radiation department should ensure implementation of the querying doubtful points procedure.

3-3. Status of statistical collection, review, and recording of examinations and querying doubtful points on request slips

The monthly number of querying doubtful points in the 31 facilities that reviewed and recorded the querying doubtful points were 963 queries. Among them, the instructions were changed, added, or deleted in 573 queries (59.5%), indicating that physicians/dentists considered that their request contents needed to be changed in response to the querying doubtful points raised by radiological technologists. This not only indicates the usefulness of querying doubtful points, but is also likely to contribute to promotion of team medicine practiced with mutual understanding with physicians/dentists, and sharing of patient information, as well as to improve the quality of medical safety. Regarding the breakdown of prescription queries, the side of examination/treatment (left/right/upper/lower/both) was most frequently queried (257 queries/month). It is acceptable to interpret that these are formal querying doubtful points, such as inquiry of imperfect writing. Although such ambiguities may not arise if the requesting physician/dentist is careful, querying doubtful points by radiological technologists are likely to help prevention of medical accidents. On the other hand, it is acceptable to interpret that querying doubtful points for method, site, range, position, interactions, contrast medium, drug reaction or its possibility, etc., include elements requiring expertise of imaging and therapeutic radiology. Regarding the influence in the case of practicing examination/treatment according to the instruction before change, in other words, queries in which no querying doubtful points is raised, was observed in 651 queries/96 facilities. The number of queries in which it was speculated that a health hazard would have occurred for the patients or that the physician's/dentist's intended results would not have been obtained was found in 543 queries/89 facilities. This indicates that practice of querying doubtful points is likely to bring about a very high advantage to patients and medical facilities.

3-4. Trends in querying doubtful points

Regarding the trend leading to querying doubtful points, queries tended to go to specific persons among those who issued request slips, and specific departments. As for specific physicians/dentists, a likely cause is that no systematic medical safety education is implemented. However, it is necessary to construct a system in which even the specific physicians/dentists are unlikely to make errors. For that purpose, the errors made by the specific physicians/dentists need to be analyzed in detail. As for the specific departments, we consider that the cause may be the busyness of the outpatient/inpatient services and requests for examination based on specificity of the departments (erroneous writing of left/right/upper/lower/both, etc., erroneous writing of examination site). We consider that care should be taken to prevent erroneous writing of left and right/upper and lower (the letters in both pairs look alike in the Chinese character). It is necessary to construct a system in which these letters are expressed in Katakana, like "hidari/migi/ue/shita" instead of using Chinese characters for "left/right/upper/lower," as well as to avoid writing alongside the hidari and migi examination sites in the slip.

3-5. Detailed contributions of radiological technologists through prescription queries

When looking at contributions of radiological technologists through querying doubtful points, it was found that querying doubtful points led to prevention of wrong examinations/treatments, security of safety, and security of efficacy of examinations/treatments. Therefore, the querying doubtful points procedure for radiologic examination/treatment by radiological technologists are likely to be an effective means to improve quality of medical safety. In addition, responses such as "I could contribute to building a confidential relationship with patients and other professionals such as physicians and nurses," and "I could develop trust in the hospital/medical facilities" were frequently answered as other contributions, which are likely to lead to construction of a confidential relationship as team medicine and mutual understanding/confidence with medical professionals.

4. Conclusion

This factual survey revealed that radiological technologists performed examinations and querying doubtful points on request slips in many facilities. However, it was also found that this operation is not reviewed and recorded as prescription queries. On the other hand, with regard to the role of radiological technologists through prescription queries, it was clarified that radiological technologists contribute to ensuring medical safety as well as efficacy of examinations/treatments, because consequently wrong examinations/treatments are prevented successfully. From the above, querying doubtful points by radiological technologists are indicated to be a required and important operation in ensuring medical safety.

Acknowledgments

We appreciate the help of those in facilities nationwide who cooperated in the questionnaire survey for the present study. We also thank all of those at the Department of Radiological Technology and other faculties in our Graduate School of Nursing and Rehabilitation Sciences who cooperated with us.

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Activities of medical radiologists at a central disaster base hospital following a major earthquake

Toshiki Tateishi

Radiology Department, Sendai Medical Center, National Hospital Organization (independent administrative institution)

【Abstract】

We experienced the Great East Japan Earthquake on Friday, March 11, 2011. After the disaster, our workplace, the National Hospital Organization's Sendai Medical Center, served as a disaster base hospital and a secondary medical institution to treat those affected by the nuclear power disaster. This article reports on the activities of medical radiologists at a disaster base hospital in an area struck by multiple major disasters. Our experiences led us to consider the importance of disaster prevention training, reflect on how institutions should cooperate with each other to complete their radiology duties, and suggest ways of providing support to the affected communities.

1. Introduction

On March 11, 2011, a magnitude 9.0 earthquake—the largest ever recorded in Japan—occurred off the Sanriku Coast. This one natural disaster caused multiple major disasters, including another earthquake, a tsunami, and a nuclear accident. Three prefectures of the Tohoku region—Iwate, Miyagi, and Fukushima—were the hardest hit. Medical care in these prefectures had to be administered with no prospect of lifelines being restored. Additionally, this earthquake disaster caused major damage to power-generation facilities. All of Japan experienced power shortages, so scheduled blackouts were conducted throughout the Kanto region. This placed restrictions on medical care and led to a variety of problems.

The author's workplace, Sendai Medical Center of the National Hospital Organization, is one of 15 hospitals that form a network of advanced comprehensive medical care centered around the National Center for Global Health and Medicine, which is part of the Japanese Ministry of Health, Labour and Welfare's medical policy network. It is centrally located in the city of Sendai, which is about 2 km northeast of JR Sendai Station. This center consists of 26 medical departments and 698 beds. The hospital addresses several areas of policy medicine, including cancer, heart disease, cerebrovascular disorders, pediatric and parental medicine, designated (intractable) diseases, AIDS, and emergency medicine. It serves as a central disaster base hospital for 14 institutions in Miyagi Prefecture. After the earthquake, our hospital contributed greatly to the disaster medical care efforts by offering our facilities to the Disaster Medical Assistance Teams (DMATs)[1] so that they could complete their relief activities.

The Miyagi prefectural government has high disaster awareness due to its experiences with past earthquakes off the Sanriku Coast, and it conducts large-scale disaster drills. Moreover, the activities of the Miyagi Association of Radiological Technologists include consultations on radiation exposure and lecture courses. Various activities have been organized in response to this earthquake disaster, as well. For more information on the content of these activities, please visit the association's website (http://www.radtech-miyagi.or.jp/).

While a variety of general articles about the earthquake disaster has been published in journals and elsewhere, few reports take the perspective of the disaster victims. Such reports are sometimes seen as merely presenting academic data, which can be offensive to people from areas affected by the disaster. In addition, although radiologists performed emergency radiation surveys, their activities were unfortunately not given much mass media attention.

Here, we report on the activities of medical radiologists at Sendai Medical Center, a disaster base hospital, during the Great East Japan Earthquake. The account is slightly chronologically jumbled, but please refer to the attached figures.

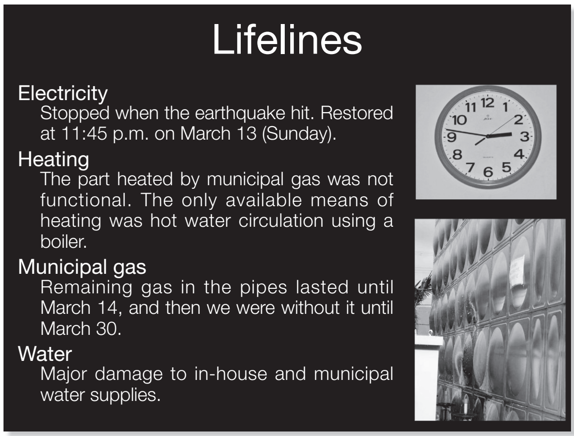

Fig. 1. Lifelines after the earthquake

2. Damage to the Hospital

At about 2:46 p.m. on Friday, March 11, 2011, Sendai's Miyagino Ward was hit by an earthquake with an intensity of 6-upper on the Japanese seismic scale. The hospital lost electricity and switched to emergency power sources. We obtained only a very small amount of information about the extent of the sustained damage from the disaster response headquarters. Later, we learned that Sendai Thermal Power Station, operated by Tohoku Electric Power Co., and other power plants had come to a halt, causing blackouts over a wide area. We began providing medical care, not knowing what the future would bring. As for the hospital's lifelines, electricity and gas lines were cut, and while there was still water available from the city of Sendai, the hospital's aboveground and elevated water tanks were damaged (Fig. 1), and this had a major effect on our care structures in the subsequent days. Emergency power was supplied using a municipal gas power generation system when the power got cut off by the earthquake until it was restored at 11:45 p.m. on Sunday, March 13. The gas supply was also cut off when the disaster struck, so we subsisted for 4 days on what remained in the pipes. If the electricity coming from the Tohoku Electric Power had been delayed, it would have placed further restrictions on the medical care we were able to provide. It took until March 28 for the municipal gas supply to return to normal.

3. The Hospital's Initial Response

After the earthquake hit, a disaster response headquarters was established, according to the hospital's manual, in a third-floor reception room. There were 606 hospitalized patients at the time, but none of the inpatients nor any staff suffered major injuries. Parts of the hospital were damaged, but not to the extent that they had to be evacuated. Seven surgeries were being performed at the time the disaster struck, and all of them were halted immediately. A triage post was set up at the front entrance, and a system was implemented with which to accept all cases brought in by emergency transport. Our hospital became a DMAT gathering base for Miyagi Prefecture, and at 6:55 p.m. on March 11, the first team arrived from Yamagata Prefectural Central Hospital. By 9 p.m. that evening, four teams had arrived. From that point until the triage post closed 6 days later, we received support from 111 teams from around Japan. Medical radiologists were part of these teams, and they served to coordinate team operations. During breaks, these radiologists would visit the radiology department to offer words of encouragement and bring snacks. Remembering those times still brings warmth to our hearts. We received much helpful advice—especially after the explosions at the Fukushima nuclear plant. Emergency medical care consisted of triage that was performed on 705 people (63 red, 223 yellow, 406 green, 3 black) in the 6 days immediately following the disaster (March 11-16).

4. The Radiology Department's Initial Response

The earthquake knocked things over and cracked some walls in the radiology department, but there was little major damage (Fig. 2). We in the radiology department also responded to the situation according to the manual by surveying the damage in each examination room and recording our observations on checklists, which were then submitted to the disaster response headquarters.

Electricity supplied via emergency power enabled us to perform simple radiographies in the emergency imaging room (Fig. 3) and take images using a portable device with a charged battery. CT, MRI, and angiography equipment was unusable, as it was not hooked up to emergency power. When the disaster hit, our hospital was mainly using film. We had enough stock for about 1 week, but it was uncertain where our next supply would come from, so we avoided developing film as much as possible and made diagnoses based on what we saw on the monitors. Although the ordering system was usable in some parts of the hospital, imaging orders were made on handwritten slips. Patient ID numbers were assigned based on the device used and order number corresponding to that date. For example, the first CT01 order on March 11 was numbered CT01031101.

Fig. 4 shows the number of imaging orders starting from when the earthquake occurred. Fig. 5 shows the number of people radiographed categorized by time. Power outages after the earthquake made it impossible to search for survivors at night, which is evident in the smaller number of imaging orders after 7 p.m. on the day of the earthquake. Search operations resumed during the daylight hours of the following day and made much progress, leading to an increase in the subsequent number of orders. Fig. 6 shows the number of people imaged by body part, and Fig. 7 shows the proportions. As the days passed, the numbers of chest and abdominal exams outpaced the bone exams. This trend appears to differ from what occurred after the Great Hanshin Awaji Earthquake[2)] .

After the earthquake, the radiology depart-

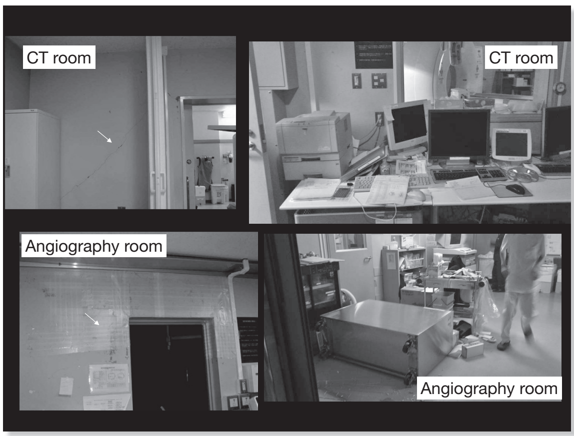

Fig. 2. State of damage after the earthquake

Fig. 3. Emergency imaging room during the disaster

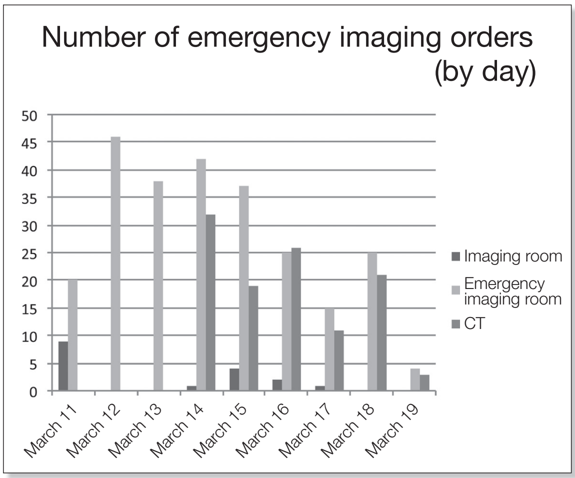

Fig. 4. Number of imaging orders after the earthquake (by day)

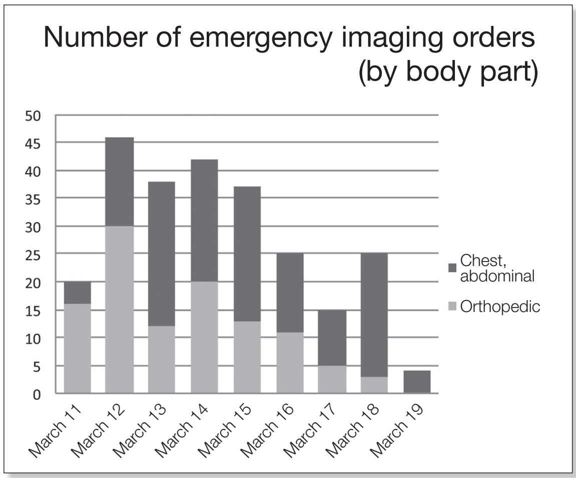

Fig. 6. Number of imaging orders after the earthquake (by body part)

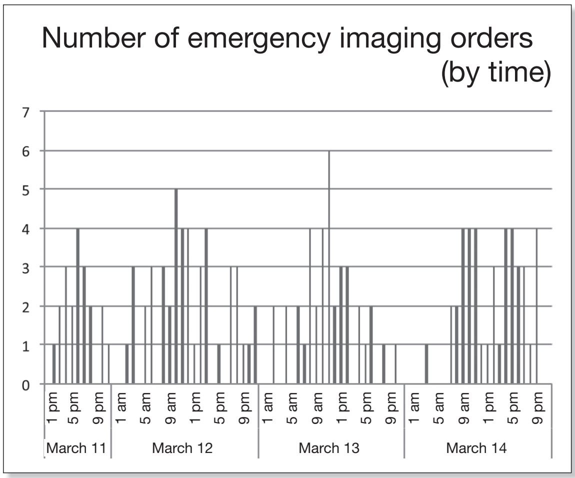

Fig. 5. Number of imaging orders after the earthquake (by time)

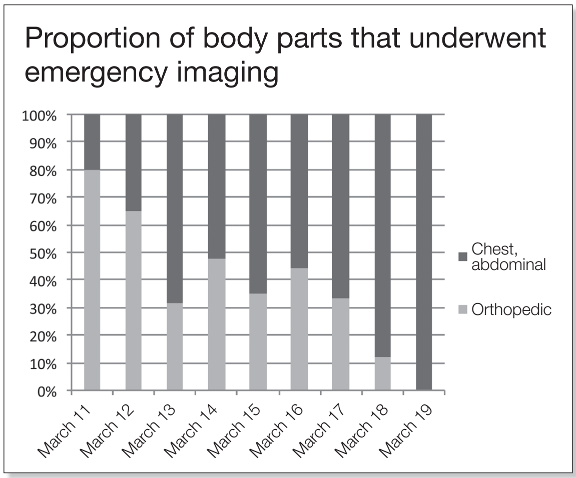

Fig. 7. Number of imaging orders after the earthquake (by body part, proportion)

ment staff confirmed their work assignments. Then, they returned home in shifts to check for damage and ensure their family members were safe before coming back to the hospital. Since we anticipated a large number of injured people being brought to the hospital, we had 3 shifts on the night of the 11th only and 4 shifts during the day and at night on the 12th and 13th, and for 3 days. Starting on the 14th, we employed the same 3-shift duty system according to which nurses work. After that, the shift system returned to normal. Most of the staff worked while cleaning up from the disaster, shopping for necessary foodstuffs, and taking care of other personal matters. Thankfully, many young, single staff members worked hard, but responding to the disaster for so long took its toll (Fig. 8). Such was the state of things at our hospital, which has a relatively large staff. At facilities with fewer employees, it must have been much more difficult.

Table: Chronological summary of the radiology department's response to the Great East Japan Earthquake

Date (day)	Time	Content
Mar 11 (Fri)	14:46	・The Great East Japan Earthquake occurs, causing power outages. The hospital switches to in-house power sources. ・Response based on Sendai Medical Center's disaster response care manual. ・Immediately after the earthquake, patient safety is assessed, and evacuations are performed, if necessary.
	15:15	・Damage to each examination room is surveyed based on a checklist.
	15:30	・Results are reported to the disaster response headquarters in the reception room. ・Equipment usable on in-house electricity: general imaging device (1 unit) in the emergency imaging room, a portable device (1 unit), and imaging devices in the operating theater.
	16:00	・Personnel assignments are made based on an anticipated large number of injured people being brought to the hospital. 11th (Fri) night: 3 shifts 12th (Sat) day and night: 4 shifts 13th (Sun) day and night: 4 shifts ・Necessary items (film, etc.) checked ・Radiation exposure records were dealt with using a disaster X-ray exposure record (handwritten). ・Retort pouch food provided by the hospital (beef rice bowl, curry).
Mar 12 (Sat)	8:30	Meeting ・A limited number of devices were re-inspected in order to reduce risk. However, due to the power outage we could not check whether they were operational. ・Device manufacturers could not be contacted by telephone for an extended period. ・Staff circumstances were surveyed. Many were unable to return home due to damage at their homes or lack of transportation. Some could not even confirm whether their families were safe. ・Imaging was performed in the general imaging room using the portable device. ・Support was provided by the radiology department staff's family members in the form of prepared food.
	15:36	・A hydrogen explosion occurs at Reactor No. 1 at the Fukushima Daiichi nuclear power plant.
	19:00	・Now having the nuclear disaster to consider, our response was based on a flowchart guiding medical care for secondary radiation exposure and early-stage radiation exposure in a nuclear disaster response manual. ・Measurements of atmospheric dose rates begin (indoors and outdoors). ・Retort pouch food provided by the hospital (beef rice bowl, curry).
Mar 13 (Sun)	8:30	Meeting ・Personnel assignments made for the following 3 days. 14th (Mon) day and night: 3 shifts 15th (Tue) day and night: 3 shifts 16th (Wed) day and night: 3 shifts ・Established the agenda for the person in charge of acute radiation exposure screenings. ・Support provided by radiology department staff and their families in the form of prepared food. ・Some staff had to evacuate their homes with their families due to severed lifelines and took refuge in the hospital.
	23:45	・100 V power source restored
Mar 14 (Mon)	3:00	・200 V power source restored
	4:30	・Use of X-ray CT device begins (1 of 2 devices)
	8:30	Meeting ・Use of the general device begins ・The staff cafeteria is opened to the public and meal service begins (porridge, etc.). This continues until April 5. ・Scheduled radiographs are halted, and only emergency exams are performed. ・We prepare to serve as a secondary medical institution for the nuclear power disaster (administrative officials are included in this process). ・Preparation for acute radiation exposure screenings (Tyvek protective gear, etc.) ・Start of acute radiation exposure screenings.
	11:01	・A hydrogen explosion occurs at Reactor No. 3 at the Fukushima Daiichi nuclear power plant.
Mar 15 (Tue)	6:14	・Another hydrogen explosion occurs at Reactor No. 2 at the Fukushima Daiichi nuclear power plant.

	8:30	Meeting ・Use of the DSA device begins. ・Use of the X-ray television device begins. ・A lack of film is anticipated, so orders are sent directly to manufacturers, and not SPD(Supply Processing & Distribution). ・Food is provided (rice balls)
	9:00	・Maximum 11,930.0 (μ Sv/h) measured at the front gate of the Fukushima Daiichi nuclear power plant.
	9:38	・Fire breaks out at the No. 4 reactor at the Fukushima Daiichi nuclear power plant.
Mar 16 (Wed)	8:00	・Vapor is emitted from the No. 3 reactor at the Fukushima Daiichi nuclear power plant.
	8:30	Meeting ・Use of an MRI device begins (1 of 3 devices) ・Food is provided (sliced bread) ・Personnel assignments are set for the following 5 days. 17th (Thu): regular day shift, 2 staff at night 18th (Fri): regular day shift, 2 staff at night 19th (Sat): regular day shift, 2 staff at night 20th (Sun): regular day shift, 2 staff at night 21st (Mon): regular day shift, 2 staff at night
Mar 17 (Thu)	7:30	・Soil sampling begins inside the hospital grounds and measurements are made of the surface contamination density of the parking lot asphalt. ・Whole-body counter measurements begin.
Mar 22 (Tue)	8:30	Meeting ・Regular day and night shifts begin this week. ・Certificates are issued in response to requests from individuals who have requested radiation exposure measurements. ・ ^{131}I is detected in a sandbox at a nursery school. Play in sandboxes was temporarily prohibited. ・A supply of radioisotopes is reestablished, and isotope exams begin. * All devices are usable, starting today.
Mar 24 (Thu)	8:30	Meeting ・Miyagi Prefecture (nuclear safety section: 022-211-2606) requests we continue acute radiation exposure screenings for the time being. ・An individual is assigned the responsibility of ensuring that the acute radiation exposure screenings are carried out for the next 2 weeks.
Apr 14 (Thu)	16:00	・The measurement of ^{131}I in nursery school sandboxes goes below the detection limit.

Fig. 8. Exhausted staff members getting some rest

5. Responding to Acute Radiation Exposure

Our hospital's acute radiation exposure manual is based on a hypothetical accident occurring at the Onagawa nuclear plant, which is operated by Tohoku Electric Power, and we trained and exchanged information with the company. Miyagi Prefecture also allocates funds in its budget to respond to acute radiation exposure. However, this earthquake disaster involved hydrogen explosions at the Fukushima Daiichi nuclear plant. Our hospital was active in providing care as a secondary medical institution for the nuclear disaster. We

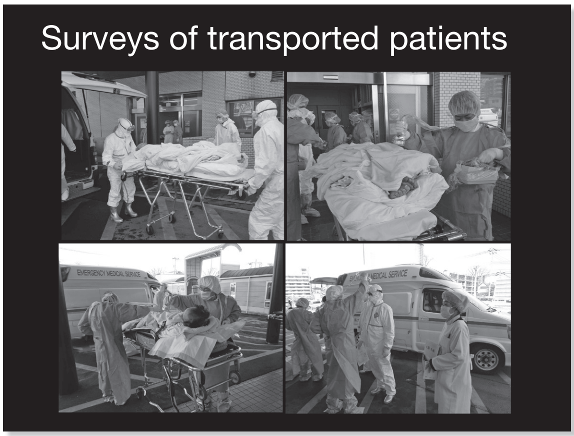

Fig. 9. Surveying patients brought by emergency transport

cooperated with the Miyagi prefectural nuclear safety office, and our response was based on a flowchart showing medical care practices for secondary and early-stage radiation exposure in a nuclear disaster response manual. This manual can be found on the website of the Tohoku branch of the National Hospital Organization of Radiological Technologists (http://www.nhort.jp/tohoku/saigai/manu.html) (in Japanese).

In addition, we took environmental measurements. From March 13 to May 8, we performed surface contamination screenings on 141 people and measured internal radiation exposure in 36 people (Fig. 9). However, as described above, earthquake damage to the hospital's water tanks prevented us from using water freely. Fortunately, no patients required decontamination. During this time, we were unable to contact other radiation research facilities, so we tried to work with other medical institutions in the prefecture. In the future, some kind of national contact mechanism should be created. Furthermore, we offered to aid in the process of performing surveys were made, despite the lack of staff in the areas hit by the disaster.

We believe there is an urgent need for policies that govern responses to nuclear power accidents. Moreover, the administration and nuclear power-related companies should be required to budget for and cooperate on the maintenance, regular inspection, and repair of survey meters. The disaster-hit areas have insufficient resources, so it is also necessary to build cooperative strategies with neighboring prefectures.

6. The Importance of Training

Our hospital performed regular training involving the entire facility, as well as administrative institutions, on disaster medical care and response to acute radiation exposure. Our disaster response was immediate because it occurred during the daytime shift. When I was transferred to this hospital five years ago, I was surprised at both the quality and amount of training conducted, which even involved actual helicopters. This training proved very helpful in preparing me to face this disaster. Other institutions no doubt have conducted trainings and prepared manuals, but it is important that all staff members be informed of these endeavors. Employing risk-reduction methods and troubleshooting is also a valuable disaster-readiness strategy. Furthermore, manuals should be available in both electronic and paper format, and they should be stored in several separate areas. When a disaster hits, it might not be possible to gain access to some manuals (Fig. 10).

7. Issues in Disaster Medicine

When a disaster strikes a large area, medical institutions in affected areas where lifelines have been cut may not be fully prepared to provide medical care for large numbers of severely injured patients. In these situations, it may be necessary to transport patients outside the affected area and perform radical treatments. Imaging diagnostics performed as part of primary surveys based on the Japan Advanced Trauma Evaluation and Care guide-

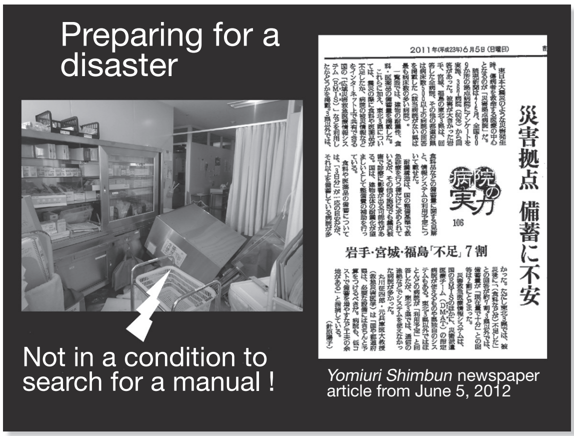

Fig. 10. Factors of concern at the time of a disaster. It may be impossible to access a manual after a disaster.

lines require a portable device for chest and pelvic radiographs. Medical institutions in disaster areas should have the necessary equipment to enable them to perform such surveys. In this earthquake disaster, however, since it took a long time to bring the patients experiencing hemorrhagic shock from distant areas to the hospital, we acutely felt the importance of having operational CT and angiography equipment. If power sources will allow, it would be best to have at least one CT or angiography device available that can run on emergency power.

As for communication networks, telephones and email were almost completely non-functional, so communication between disaster base hospitals was conducted using MCA wireless networks. The earthquake severely damaged the landline and network infrastructure. Networks fell as communications structures were destroyed and fuel and batteries for in-house power generation were exhausted. Medical institutions had enough staff after this earthquake hit because it occurred during regular working hours. If it had struck outside regular working hours, obtaining sufficient staff would have been a major problem. Thus, developing an adequate contact system is an issue that needs to be addressed.

In addition, not only radiology equipment but many other types of medical devices need to be inspected before they are utilized. In less populated areas, it might also be difficult to secure repair personnel. In this earthquake disaster, it was difficult for our hospital to secure repair personnel, even though we are located in Sendai where many companies have support centers. Nevertheless, many corporate vendors we had longstanding working relationships with provided aid. This showed us how vital personal connections are, and it underscored the importance of considering every available support system when choosing which devices to obtain and use in less-populated areas.

Securing power sources has become an important issue since most equipment has been digitized in recent years. When scheduled blackouts were announced after the earthquake, medical institutions rushed to reduce electricity usage and secure power through in-house generation. Staff should understand roughly how much power a single device requires and how much power would be required to operate a minimum system. It is essential to ensure that systems can run on only the electricity supplied from in-house power generation.

After the earthquake, we experienced problems such as supply delays due to a lack of resources and to repair personnel who were unable to come because of lack of fuel. A June 5, 2012, article in The Yomiuri Shimbun newspaper that was part of a series on hospitals described problems with insufficient inventory, even at disaster base hospitals (Fig. 10). We had enough stock for 3 days, but after this earthquake it took about a week until a certain amount of necessary supplies could be reestablished. Hospitals of our size should probably stock enough excess material to last about 1 week.

Moreover, the most important thing to remember in disaster situations that last for extended periods is that the staff members are also disaster victims. The people of Tohoku are known for their stoicism and rarely complained. Still, the longer the people were faced with the severe damage and the longer they had to protect their families, the more psychologically taxing it became. Care efforts should also be focused on these individuals.

I have heard that associations of physicians, pharmacists, nurses, laboratory technicians, and others established personnel and support systems after the Great Hanshin Awaji Earthquake. The Japan Association of Radiological Technologists and the National Hospital Organization should take the lead in organizing such initiatives within our community.

8. In Conclusion

Unanticipated problems arise whenever natural disasters hit. Nonetheless, disaster response training during normal times is essential to minimize the detrimental effects of these unexpected disasters. Moreover, the creation of person-to-person networks is also important so that help can be provided in times of trouble. We should also consider the best course of action for medical radiologists to take during such disasters and how to best support their efforts.

9. Acknowledgments

We are sincerely grateful to everyone who offered monetary or material donations or words of comfort after the Great East Japan Earthquake. Although my home was half destroyed, which made me a disaster victim, I am grateful for the opportunities given to me by my director and editors.

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31F World Trade Center Building. 2-4-1,

Hamamatsu-cho, Minato-ku, Tokyo. 105-6131

TEL: +81-3-5405-3612　FAX: +81-3-5405-3613

http://www.jart.jp

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