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英訳したものです．

Regarding Publication of the English Edition

Yasuo Nakazawa (President)

The journal of the Japan Association of Radiological Technologists (JART) has a monthly circulation of around 30,000 copies, and has been well received by our members and the public. The JART journal fulfils three major roles. First, in collaboration with the Japanese public and medical professionals, it publishes seminars on lifelong learning, thereby improving access to high-quality medical technology. Second, it publishes field-specific information on scientific technology and clinical radiology-related research papers written by JART members. Third, through the preface and introduction of the journal, it stimulates discussion on future possibilities for medical care in Japan, and on how clinical radiologists can contribute to the wellbeing of the nation.

To give our radiological technologists from across the globe an insight into our business, I will briefly explain the history of JART. In March 1896, we succeeded in taking the first X-ray image in Japan. In 1897, Shimadzu Corporation released an X-ray generator for educational use. In 1925, there were approximately 1,500 X-ray technicians. In 1927, the first Shimadzu X-ray Technician Training Institute was established, and evidence-based education was put in place. JART was founded in 1947 to make “radiological technologist” a national qualification. Since its establishment, we have worked towards broad acceptance of this national qualification, in collaboration with the government, the Diet, the Japanese Medical Association, and occupational military authorities.

As a result of our blood, sweat, and tears, in June 1951, we were finally able to see the promulgation of the Radiology X-ray Technicians Act, Act No. 226 of 1951. Since then, we have responded to the changing needs of the society, revising the original act to get the Radiology X-ray Technicians Act of 1968 passed, and partially revising that to get the Radiology Technicians Act and Radiology X-ray Technicians Act of 1983 passed, and finally getting the Radiology Technicians Act, which is in place currently, passed. Back then, the scope of work was limited to general X-ray testing, television X-ray testing, angiography, X-ray computed tomography scanning, RI scanning, and radiation therapy. In 1993, the Radiology Technicians Act was further revised, and MRI scanning, ultrasonic testing, and non-mydriatic fundus camera examination were added to the list. In 2010, image interpretation assistance, radiation examination explanation, and consultation work were added. In April 2015, intravenous contrast agent injection using automated contrast injectors, needle removal and hemostasis, lower digestive tract examination (anal catheter insertion and administration of contrast medium), anal catheter insertion, and oxygen inhalation during radiation therapy were further added as new operations that could be performed by radiological technologists.

JART will continue to respond to the needs of the medical industry, and we hope to broaden the operational scope of radiological technologists based on our foundation in scientific evidence. We will feature clinical, educational, and research-based achievements by radiological technologists in the monthly issues of the JART journal, and continually work to improve the magazine. I truly hope that this English edition will benefit radiological technicians worldwide.

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Operation and accuracy verification of image interpretation assistance by radiological technologists

Junichi Tsudukihashi[1),]**Yoshihiro Shiroishi**[1),]**Koji Hoshi**[2)]

1) Department of Radiological Technology, Public interest foundation corporation Hoshi General Hospital
2) Department of Radiology, Public interest foundation corporation Hoshi General Hospital

Key words: image interpretation assistance, radiological technologists, image interpretation conference

【Abstract】
In June 2016, our hospital initiated image interpretation assistance. As part of the procedure, image interpretation discussions were conducted by a radiologist for 30 minutes each week for 2 years to improve the ability of interpreting images. I decided to include comments on image interpretation observations in the Radiology Information System (RIS). The overall concordance rate of observations with a radiologist was approximately 88% based on the results of the accuracy verification of images and interpretation observation comments six months since starting image interpretation assistance. In addition, no statistically significant difference was observed between the concordance rate and the years of experience of the radiological technologists. In the questionnaire provided to doctors, evaluation for image interpretation assistance by the radiological technologists was high.

Introduction

On April 30, 2010, the Medical Director General of the Ministry of Health, Labour and Welfare "About promotion of team medicine by collaboration and cooperation of medical staff" (medical consultation 0430 No.1) clearly stated the additional role of radiological technologists in image interpretation assistance and explanation of examination.

I believe that radiological technologists should be involved in medical teams. However, the implementation of such assistance in the setting of real-life hospital management remains unknown.

There are various forms of image interpretation assistance, and description of abnormal findings in gastric radiography, mammography, nuclear medicine examinations, etc., which are normally performed in the work place, are also considered to be part of image interpretation assistance work. At our hospital, we still cannot afford the time to implement image interpretation assistance work by radiological technologists on regular working days, and imaging diagnosis by radiologists at any time needs to be conducted from time to time.

In the Fukushima radiological technologists association scientific meeting in February 2014, under the Masakazu Shinzato academic committee chairman (now Fukushima radiological technologists association chairman), a symposium of the image interpretation assistance was held. The contents of the symposium were as follows: -

"About image interpretation assistance in diagnostic imaging"

Mr. Kyoichi Kato
(Showa Graduate School of Health and Medical Science)

"Practice of keeping interpretation in emergency area"

Mr. Daisuke Unai
(St. Luke's International Hospital)

"Efforts toward skill improvement of image interpretation assistance"

Mr. Keiji Sakashita
(Rinku General Medical Center)

In this symposium, it was considered appropriate to utilize image interpretation assistance in emergency medical care, and the role of image interpretation assistance work at our hospital became clear. In many institutions, although radiological technologists are in attendance at night or on closed days, radiologists are not, and if image examination needs to be done during this time, doctors in charge at that time often perform the interpretation. In addition, the doctor in charge at that time often carries out image interpretation outside his/her specialized field, and it is presumed that his/her diagnosis will be accurate. In addition, there are times when a doctor working at night is a medical intern, and under such circumstances, a radiological technician who observes images on a daily basis is required to identify abnormal findings more efficiently.

1. Purpose

When the radiologist is absent, image interpretation assistance by radiological technologists at our hospital is performed based on computed tomography (CT) and magnetic resonance imaging (MRI) scans generated. In view of this, we aimed to improve the interpretation ability of diagnostic radiological technologists and operation of image interpretation assistance work, verify the accuracy of image interpretation assistance work by radiological technologists, and evaluate image interpretation assistance work performed by doctors.

2. Method

2-1. Improve interpretation ability

To perform image interpretation assistance, we believed that the interpretation ability of individual radiological technologists had to improve, and thus, since April 2014, in luncion format once a week, image interpretation discussions with radiologists were initiated. The contents of the discussion were as follows.

- A radiologist selected cases based on past examination and commentary.
- Commentary repeated high frequency and urgency cases.
- Commentary on cases where radiological technologists found it difficult to interpret image.
- Radiological technologists are advised on image reconstruction.
- The person in charge of records and keeps the contents on the day.

For those radiological technologists who were unable to participate in image interpretation discussions because of being on vacation etc., the content of the image interpretation discussion should be checked at a later date.

Although the image interpretation discussion is now also conducted with the aim of improving the image interpretation ability of radiological technologists, the awareness that describes the interpretation findings comment after the examination.

2-2. Procedure of image interpretation assistance work

To prepare the image interpretation assistance work, operating regulations were established. An accurate reporting to the doctor, convenience of image interpretation assistance work by radiological technologists, further education of radiological technologists, etc., were formulated, and operational policy of the following contents was formulated.

- As a form to be reflected in the electronic medical record, a comment on the image interpretation findings is included in the examination comment column of RIS.
- Describe only the lesion and condition related to the main complaint.
- Use disease name.
- Radiological technologists describes the state the name of its own.
- Priority is given to the examination and photography.
- Ensuring that the content and format of the

technician's report will have no legal implications.

In addition, explanation was provided to the doctor on duty to obtain approval on the secondary emergency designation day. By adding one work system of radiological technologists, we prepared the image interpretation assistance work system, and in June 2016, we started using the image interpretation assistance provided by more radiological technologists.

2-3. Verification of the accuracy of image interpretation assistance by radiological technologists

In order to verify the accuracy of interpretation assistance by radiological technologists, we verified 1,027 cases of image interpretation assistance for which the name of the technician was specified during the 6-month period from June 2016 when interpretation assistance was initiated to November 2016. The referral of the image interpretation reports was approved by the hospital ethics committee.

The included radiological technologists were divided into three groups depending on the years of experience of the radiological technologists who performed image interpretation assistance:

- ≥10 years (n = 6)
- 5–10 years (n = 7)
- <5 years (n = 10)

The items to be considered were as follows:

· Number and average of comments provided during image interpretation assistance by radiological technologists.
· Number and rate of consistent comments between radiological technologists and radiologists.
· Number and rate of inconsistent comments between radiological technologists and radiologist.
· Number and rate of over-reported comments by radiological technologists.
· Number and rate of differences in interpretation between radiological technologists and radiologists.

The data obtained were analyzed by the Kruskal-Wallis test and the post-hoc test using the free statistical analysis software Easy R (EZR). $P < 0.05$ was considered significant.

The aggregation and analysis were performed by one author.

2-4. Evaluation of image interpretation assistance work by a doctor

A questionnaire (shown in Table 1) was administered to a doctor who analyzed the image interpretation assistance work performed by the radiological technologists. In addition, the questionnaire was bearer and went in free-form submission.

Table 1 Questionnaire to medical doctors involved in image interpretation assistance

1, Please specify your work type
Medical Doctor ☐Emergency work (+)
☐Emergency work (-)
☐Medical intern
2, Did you know that radiological technologists are performing image interpretation assistance work?
☐Known ☐Neither
3, What do you think about this effort?
☐Evaluated ☐Evaluated a little
☐Neither ☐Not much evaluated
☐Not evaluated
4, What do you think about the content of the comments?
☐Satisfied ☐Slightly satisfied
☐Neither ☐Not so much satisfied
☐Not satisfied
5, Radiological technologists record the name of the disease in the comment. What do you think about that?
☐Lucid ☐Lucid a little ☐Neither
☐Better not use ☐Not use
6, Do you refer to the comments?
☐Always reference ☐Rarely for reference
☐Neither ☐Not much reference ☐Not reference
7, Are there cases in which the comments were useful?
☐Yes ☐No
8, Do you think that this approach should continue in the future?
☐Should continue ☐Neither ☐Should stop
9, If you have any other requests, please write.
( )

3. Results

3-1. Improved image interpretation ability

Since initiating interpretation discussions, it took approximately 2 years for radiological technologists to begin image interpretation assistance. Originally, it was planned to begin image interpretation assistance from the first year since initiating interpretation discussions. However, less-experienced radiological technologists are often hesitant to write comments about their interpretation of the findings. After one year's experience, we attempted to dispel this sense of hesitance to increase their confidence in the interpretation process.

3-2. Performing image interpretation assistance

As a method of reflecting in the examination field mentioned in the electronic medical record, although the interpretation finding comment is described in the examination comment column of RIS, the description is completed within 10 minutes after examination in almost all cases. Because the description of the comment is completed in a relatively short time, not all abnormal findings are described; only the lesion and pathological condition considered to be related to the main complaint are described (for example, if the chief complaint is breathing difficulty, the description would not comment on whether liver cysts or renal cysts existed), and because descriptive expressions are mentioned using disease names, inputs can be simplified. Furthermore, because the number of examinations was high on the secondary emergency designation day, it is considered that one of the major factors was the increase in the number of personnel.

In contrast, by specifying the name of the person in the examination comment column, we believe that the quality of the interpretation finding comment can also be ensured. Such a requirement would place an onus of responsibility on the technician and would probably improve standards. In addition, the entry of the interpretation in the electronic medical record would mean easy accessibility for doctors at any time and place.

3-3. Verification of the accuracy of image interpretation assistance work performed by radiological technologists

Table 2 shows the overall accuracy of interpretation finding comments by radiological technologists.

Table 2 Accuracy of image interpretation assistance by whole radiological technologists

consideration item	Number (rate)
number of interpretation assistance	1,027
number of comment	1,620
average number of comment	1.6
number of consistent comment	1,427
rate of consistent comment (%)	88.1
number of inconsistent comment	377
rate of inconsistent comment (%)	18.9
number of overreported comment	137
rate of overreported comment (%)	8.5
number of differences of interpretation	55
rate of differences of interpretation (%)	3.4

In the 6-months from June 2016 to November 2016, the total number of image interpretation records in which the name of the radiological technologists was specified was 1,027, among which the number of comments that the radiological technologists pointed out as a finding was 1,620. Each report contained an average of 1.6 comments. Incidentally, the case of "no abnormal finding" was also included in the number of comments. Among the 1,620 comments, the number of consistent comments by the radiologist was 1,427; thus, the rate of consistent comment was 88.1%. In the diagnostic comments of radiological technologists, 377 items of pathological conditions that were related to the main complaint were considered to be inconsistent, and the rate of inconsistent comment (number of inconsistent comment/(number of comment + number of inconsistent comment)) was 18.9%. The number of radiological technologists with over reported comments was 137; the rate of over reported comments (number of over reported comments/number of comments) was 8.5%. Although radiological technologists and the radiologist identified similar findings, there were differences in the interpretation of the findings. The number of differences in interpretation was 55, and the rate of differences in interpretations (number of differences in interpretation/number of comments) was 3.4%.

Fig.1 shows the number of image interpretation assistance work grouped according to the years of experience of radiological technologists and the results of examining five items.

There were 253 cases of interpretation assistance work grouped according to radiological technologists' experience of ≥10 years, 301 cases for 5–10 years, 473 cases for <5 years. The number of comments in image interpretation assistance work was 405 for radiological technologists with ≥10 years of experience, 444 for those with 5–10 years of experience, and 771 for those with <5 years of experience. When the Kruskal-Wallis test was performed on the number of comments, the P value was 0.2, with no significant difference observed among the 3 groups. The average number of comments was 1.6 for radiological technologists with ≥10 years of experience, 1.48 for those with 5–10 years of experience, and 1.63 for those with <5 years of experience.

For the number and rate of consistent comments between radiological technologists and radiologists, the number of consistent comment was 372 for radiological technologists with ≥10 years of experience, 397 for those with 5–10 years of experience, 658 for those with <5 years of experience. The rate of consistent comment was 91.9% for radiological technologists with ≥10 years of experience, 89.4% for those with 5–10 years of experience, and 85.3% for those with <5 years of experience. P value = 0.216 next was subjected to Kruskal-Wallis test in rate of consistent comment, there were no significant differences among the three groups.

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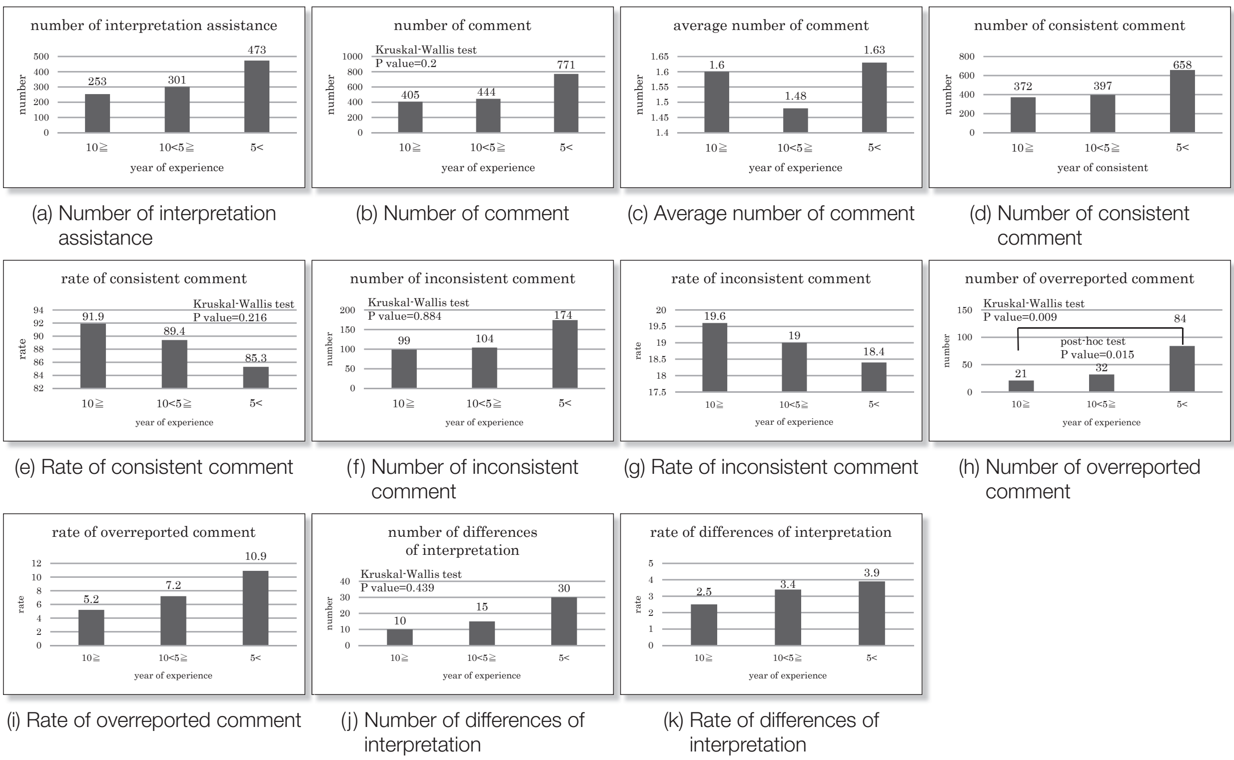
For the number and rate of inconsistent com-



(a) Number of interpretation assistance
(b) Number of comment
(c) Average number of comment
(d) Number of consistent comment
(e) Rate of consistent comment
(f) Number of inconsistent comment
(g) Rate of inconsistent comment
(h) Number of overreported comment
(i) Rate of overreported comment
(j) Number of differences of interpretation
(k) Rate of differences of interpretation

Fig.1 Difference in accuracy depending on experience years of radiological technologists in image interpretation assistance ments on findings not identified by radiological technologists but identified by radiologists, the number of inconsistent comments was 99 for radiological technologists with ≥10 years of experience, 104 for those with 5–10 years of experience, and 174 for those with <5 years of experience. The rate of inconsistent comment was 19.6% 99 for radiological technologists with ≥10 years of experience, 19.0% for those with 5–10 years of experience, and 18.4% for those with <5 years of experience. P value = 0.216 next was subjected to Kruskal-Wallis test in number of inconsistent comment, there were no significant differences among the three groups.

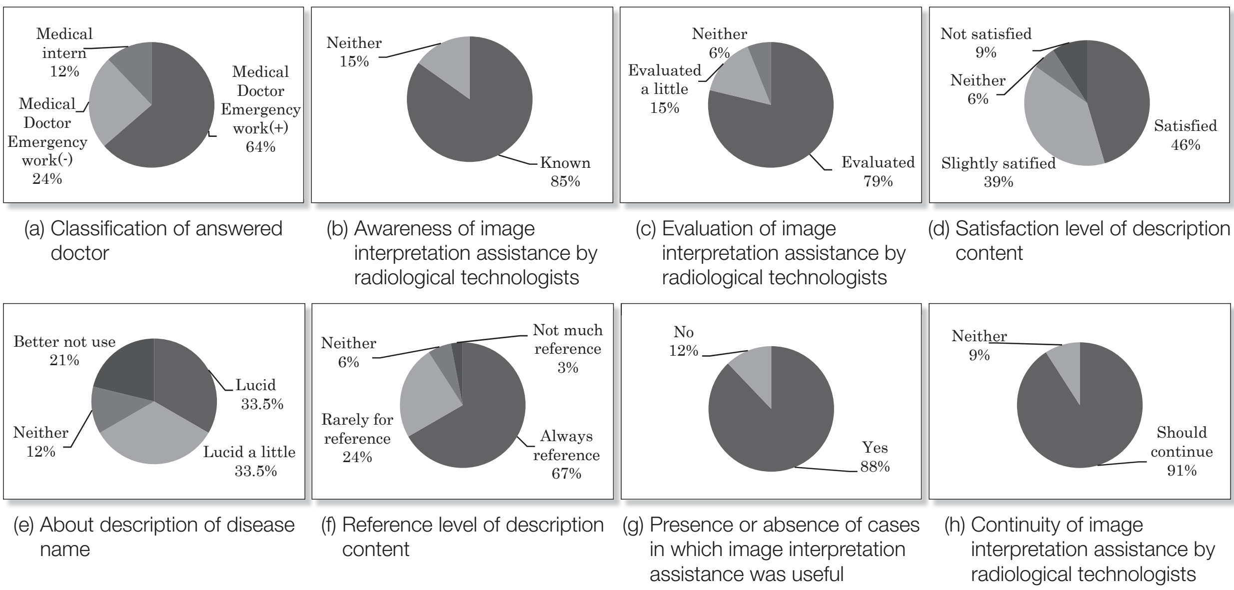
For the number and rate of over reported comments on findings identified by radiological technologists but not by radiologist, the number of over reported comments was 21 for radiological technologists with ≥10 years of experience, 32 for those with 5–10 years of experience, and 84 for those with <5 years of experience. The rate of over reported comments was 5.2% for radiological technologists with 10 years or more experience, 7.2% for those with 5–10 years of experience, and 10.9% for those with <5 years of experience. When the Kruskal-Wallis test was performed to assess the number of over reported comments, the P value was 0.00946. Because a significant difference was observed among the 3 groups, the post-hoc test was performed and analysis was performed between the 2 groups, and a significant difference was observed (P value = 0.015) for radiological technologists with 10 years or more and <5 years of experience.

For the number and rate of differences in interpretation of findings by both the radiological technologists and radiologist, the number of differences in interpretation was 10 for radiological technologists with ≥10 years of experience, 15 for those with 5–10 years of experience, and 30 for those with <5 years of experience. The rate of differences in interpretation was 2.5% for radiological technologists with ≥10 years of experience, 3.4% for those with 5–10 years of experience, and 3.9% for those with <5 years of experience. P value = 0.439 next was subjected to Kruskal-Wallis test in number of differences of interpretation, there were no significant differences among the three groups.

3-4. Evaluation of image interpretation assistance work by a doctor

Fig.2 shows the evaluation of image interpretation assistance work performed by a doctor who worked in the hospital.

The total number of doctors who responded



(a) Classification of answered doctor
(b) Awareness of image interpretation assistance by radiological technologists
(c) Evaluation of image interpretation assistance by radiological technologists
(d) Satisfaction level of description content
(e) About description of disease name
(f) Reference level of description content
(g) Presence or absence of cases in which image interpretation assistance was useful
(h) Continuity of image interpretation assistance by radiological technologists

Fig.2 Evaluation of image interpretation assistance by medical doctor to the questionnaire was 33: 21 were engaged in emergency services (64%), 8 were not engaged in emergency services (24%), and 4 were interns (12%). Among them, 28 doctors recognized (85%) and 5 doctors did not recognize (15%) that radiological technologists were doing image interpretation assistance work.

Regarding the assessment of radiological technologists approach to image interpretation assistance work, we evaluated 26 people (79%), evaluate a little 5 people (15%), but 2 people (6%) who do not think at all It was.

Regarding the content of the comment stated as satisfied, 15 people (45%) were slightly satisfied, 13 (39%) were neither, 2 (6%) were not satisfied, and 3 (9%) were.

Regarding that radiological technologists describing disease names, although it is lucid to understand, 11 people (33%), which is lucid a little to understand, 11 people (33%), neither to understand 4 people (12%), although it is preferable not to use 7 people (21%).

Regarding whether the described comment is referring, 22 people (67%) are always referring, 8 people (24%) referring rarely, 2 people (6%) but neither, 1 people (3%) not much referring.

Regarding the presence or absence of cases in which the described comment was useful, 29 people (88%) found it helpful and 4 (12%) did not.

Regarding whether to continue this effort in the future, 30 people (91%) responded that it should be continued but 3 (9%) did not agree.

Several other comments described in the requested matter were as follows.

- I am worried whether the responsibility will be imposed on the radiological technologists.
- It is received as a reference level to the last.
- Ability to interpret in emergency situations and whether time is thus saved.
- It is very helpful in terms of preventing oversight.
- Because opinions on findings do not necessarily agree with each other, they are drawn to the description, so I think that it would be better to limit the findings if possible.

4. Consideration

To initiate image interpretation assistance by radiological technologists, we started the image interpretation discussions, but the understanding and cooperation of radiologists was indispensable for this. With the staff being busy with daily work, we understood the purpose of our efforts, and we were extremely fortunate to be able to continue the image interpretation discussions for 30 minutes each week, which contributed greatly to improving the image interpretation ability of radiological technologists. More than anything, we believe that radiologists were actively seeking descriptions of interpretation of findings by radiological technologists.

For improving interpretation ability, study sessions among radiological technologists could be considered, but they were deemed to be impractical. Although I have been going through many times so far, there was a tendency to stay in checking the abnormality of the form by referring to the interpretation report only between radiological technologists. A radiologist would probably teach the mechanism of production of symptoms and signs in a disease, the differential diagnosis and the prognosis. Since the expertise of radiological technologists is limited to the actual taking of X-rays, some exposure to the principles of internal medicine would be of benefit, and the best professionals to instigate this are probably radiologists. There are ongoing developments in radiology in terms of new imaging techniques and the interpretation of novel radiographs. For example, it has become possible to make conclusions on the basis of appropriate changes in imaging range, contrast agent concentration and injection dose for each disease, imaging timing, and number of imaging cycles.

In my opinion, increasing the degree of reliance on technologists should be available when radiologists are not readily available to interpret images. Because even if the start of the operation of the image interpretation assistance work only in radiological technologists with a certain interpretation a certain level immediately, and when the other radiological technologists is performing the work, it is not possible to describe the interpretation comment. When the doctor side does not establish a system, which was considered a permanent work, for interpretation findings comment itself of the radiological technologists there is a possibility that no longer met as a system, in a radiological technologists everyone to do an image interpretation assistance work, I think that must be faced.

In our hospital, it took about two years from the beginning of the image interpretation discussion until radiological technologists were able to begin image interpretation assistance work. There are two possible causes for this. First, there is scope for improvement in the interpretation ability of each individual radiological technician. Interpretation ability takes time to be improved to a reasonable standard. It is necessary for a radiologist to repeatedly explain similar cases for the trainees to learn from daily work. Second, improvement in the interpretation ability of radiological technologists required a period of time until it became possible for them to describe comments with the awareness and conviction about their interpretation findings. In our hospital, we found that it takes two years of supervised training in interpretation of radiographs and correct reporting of findings before a technician becomes confident and autonomous in this role.

We also reviewed the work system. On the secondary emergency designated day, the number of medical radiological technologists on duty increased from 2 to 3. Approximately 20 cases of image interpretation assistance work occurred during the night on the secondary emergency designated day. Of course, examination and photographing were prioritized, but if interpretation finding comment is delayed, interpretation assistance work will not be established. As expected, priority is given to examination and radiography; however, delays in the reporting of the findings, if this is a result of delegation to technologists, does not favor this role for technologists. Even if CT examination or general image photographing is requested other than three persons, the other two correspond, so that it is possible to describe the interpretation finding comments immediately after the examination. By doing this, we can observe the image with a safety margin, believing that it leads to efficient and accurate descriptions of the interpretation. In addition, in the overall work structure, the number of radiological technologists has not increased, and the work will be closed the next morning.

We also examined how to convey interpretation finding comments to doctors from various perspectives. As a method, we examined the entry into the examination comment field of RIS actually done at our hospital, direct input to the electronic medical record, verbal communication by telephone, paper surface transfer by memos etc. and check sheet transmission. In direct input to the electronic medical record, we thought that there was a problem in ensuring accuracy, particularly with respect to the correct use of medical terminology. In verbal communication by telephone, depending on the circumstances, it is not always the case that the telephone is connected, so this option was rejected. The possibility of using paper-based communication by memos etc. was dismissed due to possible loss or complication of delivered memos. The input of the interpretation finding comment in the examination comment column of RIS and its reflection in the examination execution column of the electronic medical record was seen as being acceptable.

Since the technologists have no background teaching in medicine or for that matter, in the basic medical sciences, a starting point would need to include detailed teaching of the anatomy, physiology, and principles of pathophysiology, as well as the symptoms and signs of diseases. The following is a report of a scientific meeting in Kyoto in 2015 where Mr. Masatoshi Watanabe from the Medical Department of Health, Labour and Welfare presided.

"Report is of a public that only wrote the opinion of doctors in the current maintenance. In the prevailing circumstances, whereby doctors have a busy schedule yet the expertise necessary in order to correctly interpret radiographic images is lacking among ancillary staff members, the legal implications of delegating such crucial tasks to technologists are immense. It will be some time before this pilot scheme might be extended to a national level [1]."

Following the viewpoint of such a country, our hospital decided to use disease states and disease names that are easy to understand in interpretation finding comments. In recent years, attention has been drawn to a new role for radiological technologists for image interpretation assistance, but the logistics of such a venture have yet to be elucidated. In view of the proposals made by the Ministry of Health, Labour and Welfare as an academic society, it is necessary to prepare guidelines as soon as possible. As a personal opinion, from the fact that doctors are also required to regularly and appropriately perform image interpretation assistance work in the emergency department, I believe this new and additional role for radiological technologists should be introduced. A certain level of procedural rules and regulations need to be formulated that include minimum standards of reporting and a protocol of description of radiological signs. This should encompass a consensus of opinion among leading doctors at the hospital.

In the accuracy verification of image interpretation assistance work, the overall outcome coincidence ratio was 88.1%, which is a good result. I believe this is an indication of the results of the ongoing image interpretation discussion and the fact that each radiological technician at our hospital seriously responds to image interpretation assistance work.

Initially, we predicted that the accuracy of interpretation finding comments will depend on the years of experience of radiological technologists. However, although there were minor difference between the reports made by technologists with varying levels of experience, these differences were not statistically significant. We would recommend that each image be scrutinized by more than one professional, including a radiologist in difficult cases, to preserve a healthy margin of safety.

The overall rate of inconsistent comments was approximately 20%. One explanation for this discrepancy might be the need for a detailed report which may not lie within the confines of expertise of a technician. Serious signs, such as acute renal calculi or hydronephrosis, should be brought to the attention of the radiologist.

The only item for which a statistically significant difference was recognized was the number of over reported comments in the group of radiological technologists with 5–10 years of experience. This indicated that there was a tendency to excessively over report comments if the radiological technologists' experience was <5 years. This over reporting feature that became apparent in the work of less experienced technologists was probably a result of these workers having seen considerably less cases over the years. This deficiency might be rectified in the future as their exposure to a variety of cases increases.

Regarding the differences in interpretation, we understand that it was not an ideal situation. There was an obvious lack of understanding of the pathological processes that indicated various radiological signs, and this shortfall could be corrected by provision of training during the planned discussions. In the evaluation from the doctor, 85% of the recognition and approximately 94% of the evaluation were of a high standard. In the interpretation finding comment contents, 84% were satisfactory. We think that this improvement could be attributed to the training provided during discussions. Moreover, we think that it was great to refer to the interpretation report by the radiologist than daily. However, 21% of doctors tended to discourage the use of names of diseases by technologists, and we would like to make efforts to inform the operation within the hospital in future.

As far as the opinions of doctors on technologists' reports is concerned, as many as 91% referred to them and 88% said that the reports were useful. The results of the questionnaire survey on the image interpretation assistance by the Japan Association of Radiological technologists revealed that 90% of radiological technologists judged experience to be asked for image interpretation assistance from doctors, among them seeking at nighttime and emergency time it is said that about 40% of the total was done [2].

This implies that doctors also have anxiety about their own interpretation and that it was an indication that needs medical advice from radiological technologists.

Overlooking image findings is mainly a perception error (it cannot recognize abnormal findings), cognitive error (it can recognize but differences interpretation), alliterative error (dragged by findings of previously interpreted people), among them, perception error (it cannot recognize abnormal findings) accounts for 80% of diagnostic errors [3]. In recognition of this abnormal finding, we believe that a radiological technician who daily observes many images is in a position expected to be active. If the trend of technologists performing competent image interpretation work continues, this task could be approached by the whole team and might improve overall patient care in due course.

5. Conclusion

At our hospital, we initiated image interpretation assistance work by radiological technologists when radiologists were absent.

To start the image interpretation assistance work, we made efforts to increase the awareness and improve the interpretation ability of individual radiological technologists and formulated operation regulations in the hospital.

To verify the accuracy of image interpretation assistance, the overall rate of consistent comment with radiologist's interpretation findings was 88.1%, and the evaluation by other doctors was also high.

6. Acknowledgments

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Spinal Fusion Surgery Clinically Performed in a Hybrid Operating Room

Yoshinori Takao, Shohei Sasaki, Masanobu Narasawa, Shinichiro Izuta, Aoi Yasuge, Takao Ichida

Department of Radiology, Osaka City University Hospital

Key words: Spine surgery, Spinal fusion surgery, Image-guided surgery, Hybrid operating room, C-arm CT

【Summary】

Purpose: Building of a hybrid operating room (Hybrid OR) to perform minimally invasive cardiac and aortic surgeries is currently increasing in Japan; however, it is not effectively used for other types of surgeries. This paper reports cases of Hybrid OR utilization for spinal fusion surgery. Clinical experience: Our Hybrid system uses the Angio system "Allura Clarity (Philips)" and operating table "Magnus (Maquet)." We encountered 39 cases of spinal surgeries at the Hybrid OR from April 2014 to March 2016: 33 spinal fusion surgeries (including a preoperative transcatheter embolization case) and 6 without spinal fusion surgery (such as arteriovenous fistula). Experiences related to the radiological technology used in 32 cases of spinal fusion surgeries, excluding the preoperative arterial embolization case, were retrospectively evaluated. The fluoroscopy time was 2.8 ± 2.5 min, single shot was 5.3 ± 3.5, kerma area product was 27.6 ± 37.2 Gy cm^2, and the number of shot on C-arm computed tomography (CT) was 2.3 ± 1.5 times. This study showed that using the Hybrid OR system has advantages. The angiography system has a flat panel detector with large imaging field and no distortion. The C-arm CT is used to obtain a clear volume image in clinical cases that require detailed visualization of the pedicle screw and bone structures. **Conclusion**: The Hybrid OR is a useful system for various spinal fusion surgeries.

Introduction

Building of a hybrid operating room (Hybrid OR) with high-performance imaging equipment installed in the operating room is increasing in order to perform safe surgeries, decrease invasion during surgeries, and perform minimally invasive surgeries and other procedures. Computed tomography (CT), magnetic resonance imaging, and the Angio system are some of the equipment found in a Hybrid OR, which are selectively performed according to the purpose of the surgery [1]. In recent years, the mainstream of a Hybrid OR is combined with the angiography system and aimed to perform minimally invasive surgeries for cardiac or vascular diseases. Currently, the Hybrid OR is more frequently used according to the sophistication of minimally invasive cardiovascular surgeries. However, as the Hybrid OR is limitedly used only for cardiovascular surgeries, monitoring its using rate is difficult [2].

Because the Hybrid OR functions as both an operating and angiography room, it can possibly be used for various surgeries [3-6]. If only one function is used (either the operating or angiography room) and the other is not, its cost-effectiveness decreases because of not using expensive and high-functional equipment [7].

To increase the utilization of the Hybrid OR, our hospital was performing not only cardiovascular surgeries but also other various hybrid surgeries.

In the present study, the experiences of radiologic technologists during spinal fusion surgeries were reported, which supports the effectiveness of utilizing the Hybrid OR.

1. Experience on spinal surgeries

1-1. Specifications of the Hybrid OR

Our Hybrid OR was built by introducing an angiography system, namely, Allura Clarity X-per FD 20 (PHILIPS Medical systems), into an existing operating room with the surgical table MAGNUS (Maquet Japan). The Allura

Clarity X-per FD 20 has a ceiling suspension mechanism with a wide movable range of C-arm system called Flex-move, which effectively identifies various layouts that matched with various clinical needs.

1-2. Experiences

In total, 39 cases of spinal and spinal cord surgeries performed by neurosurgeons and orthopedics in the Hybrid OR from April 2014 to March 2016 were included. These cases consisted of 33 spine fusion surgeries (including a case of vascular embolization performed preoperatively) and 6 vascular diseases without spine fusion surgery (such as spinal arteriovenous malformation and spinal arteriovenous fistula). In total, there were 11 cases of cervical surgery, 3 of thoracolumbar transition, 12 of lumbar spine, 5 of idiopathic scoliosis, and 2 of spinal tumor (Table 1).

Table 1　Detail of the spine surgery*

Cervical spine	11
Include thoracolumbar junction	3
Lumbar spine	12
Scoliosis	5
Related to the tumorectomy	2
Total	33

*include a preoperative transcatheter embolization case

1-3. Layout of the Hybrid OR (Fig. 1)

The protection boards were placed in front of the anesthesiologist and the circulating nurse. The area around the operating table was sterilized; therefore, careful attention should be paid when moving the C arm. Surgeons during a spine surgery stand at both sides of the patient, which is different from the usual position of interventional radiologists. Therefore, monitors were constructed depending on the viewing requirements of the surgeons. The radiologic technologist operated the system in a position that can enable easy checking of the arrangement of the C arm and operating table. In addition, some mobile radiation protection boards were placed inside the room, and the radiation-protected area was identified and used by surgeons and scrub nurses to reduce their radiation exposure due to fluoroscopy, X-ray imaging, and C-arm CT.

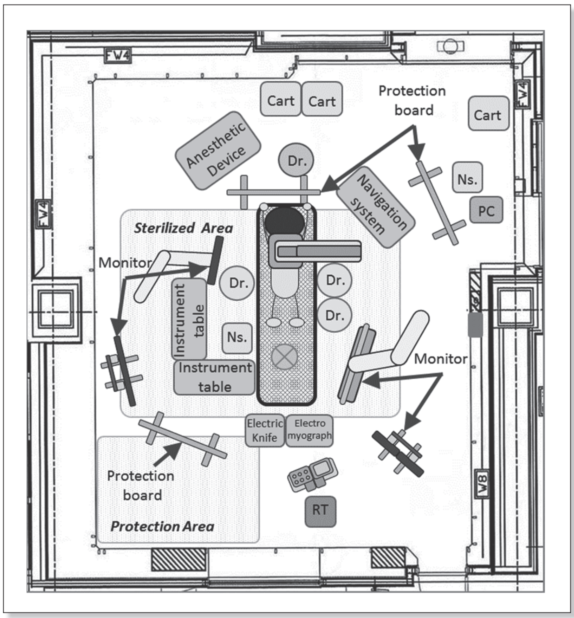

Fig. 1　Layout of spine surgery

Fig. 2　Preoperative photograph (Lumbar spine)

1-4. Support by Radiologic Technologists

Spinal fusion was performed under general anesthesia. After the induction of anesthesia in patients on supine position, the surgical field was accordingly prepared. The most common posterior fixation surgery was performed in the prone position. However, the patient's thicknesses were increased due to the thick four-point support and operating table (Fig. 2). The

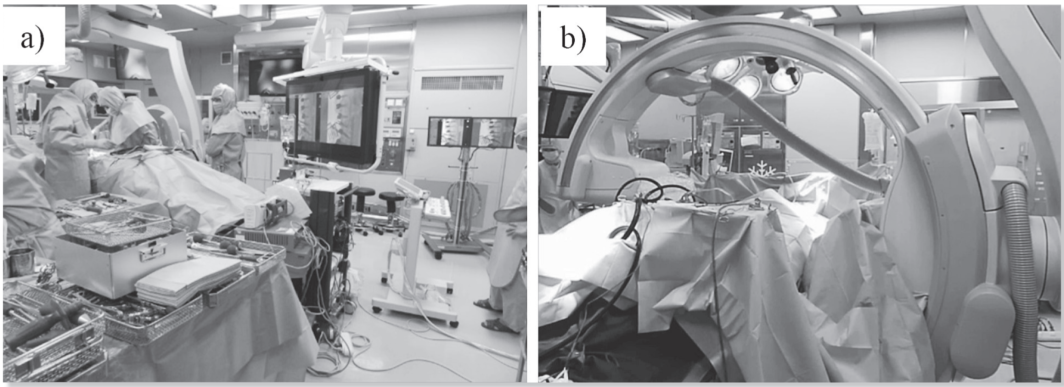

Fig. 3 Intraoperative photograph
a) Scene of the spine fusion surgery
b) Scene of performing the C-arm CT

Table 2 Scan condition of C-arm CT

Scan			
Voltage*	117-123 kV	Rot. Angle	180 degree
Current*	50-325 mA	Scan time	10 sec
Pulse width*	5-10 msec	Images	320
Inch size	19 inch	Filter	0.9 mmCu 1.0 mmAl
Reconstruction			
Filter	Stent	Matrix	512^3

*Automatically change according to match the patient

environment of the surgery was constructed with careful consideration that the procedure can be smoothly performed without altering the safety maneuver of the C-arm before draping.

Most procedures were performed using combined fluoroscopy and navigation system [8]. In complex cases, the detailed bone structure should be evaluated using the C-arm CT, with careful consideration on the maintenance of sterility in the surgical field (Fig. 3a, b).

2. Methods

Imaging methods performed during a surgery were 7.5 fps fluoroscopy, single shot, and C-arm CT for the body. This study was conducted with the approval of the Ethics Committee of our hospital (approval number: 3443).

The radiation dose in phantom-related X-ray imaging was based on the fluoroscopic dose rate, single shot, and C-arm CT imaging dose in the basic procedure. In addition, the radiation dose with spinal fusion surgery was retrospectively investigated to evaluate procedures related to radiologic technology.

2-1. Equipment

The fluoroscopic dose rate and imaging dose were measured using thimble Ion-chamber dosimeter: Radcal 9501, 6 cc (Radcal Co., Ltd.) and 20-cm acrylic plate (Kyoto Science Co., Ltd.), respectively. The C-arm CT radiation dose was measured according to the body phantom based on JIS-4915 (Kyoto Science Co., Ltd.). All of the phantom lumen was filled with water because the dose was measured depending on the body trunk.

2-2. Dosimetry

The fluoroscopic dose rate and single-shot dose measurement were performed at 19, 17, and 14.4 in. flat panel detector (FPD) size used in spinal fusion surgery. Fluoroscopic and X-ray imaging dose measurements were performed at the patient entrance reference point based on the guidelines [9]. The fluoroscopy dose measurement was performed thrice with 2-min interval. The dose rate per minute was calculated from the measured values and subsequently averaged to obtain the FPD size value. The X-ray imaging dose measurement was performed three times, and the average was calculated to obtain the FPD size value.

The C-arm CT dose measurement was performed three times based on the dose area product meter equipped on the Angio system, i.e., a 19-in. FPD size; in addition, the average was calculated.

2-3. Evaluation of the procedure

Among the 33 patients who underwent spinal fusion procedures performed in the Hybrid OR, 32 were included, excluding one patient who underwent vascular embolization performed preoperatively, in order to retrospectively investigate the fluoroscopic time, number of used X-ray imaging, dose area product, and number of used C-arm CT.

3. Result

3-1. Dosimetry

The results of dosimetry are shown in Table 3. At FPD sizes of 19, 17, and 14.4 in., fluoroscopic dose rates were 3.56, 4.39, and 4.75 mGy/min with X-ray imaging doses of 0.62, 0.81, and 0.92 mGy, respectively. The dose area product with C-arm CT imaging was 7.34 Gy cm^2.

3-2. Evaluation of the procedure

The results in evaluating the procedures are shown in Table 4. Fluoroscopy was mainly used to check the time of screw insertion. The fluoroscopy time was 2.8 ± 2.5 min (mean ± standard deviation). During screw insertion, a short fluoroscopy of approximately 1 s was repeated, and the tip position was confirmed. In contrast, during detailed screw adjustment, the position of the screw was monitored by continuous fluoroscopy. X-ray imaging was mainly used for intraoperative or postoperative evaluation of cases that could not be evaluated with fluoroscopy. X-ray imaging was performed 5.6 ± 3.5 times. The C-arm CT was used in almost all cases to evaluate the position of the screw and bone structure with the three-dimensional data. The C-arm CT was performed 2.3 ± 1.5 times, and the dose area product was 27.6 ± 37.2 Gy cm^2.

Table 3　Result of the dose measurement

	FPD size (inch)	19	17	14.4
Fluoroscopy*	Voltage (kV)	76	78	79
	Current (mA)	2.4	2.6	2.9
	(mGy / min)	3.56	4.39	4.75
Single shot*	Voltage (kV)	80	80	80
	Current (mA)	8	11	13
	(mGy / time)	0.62	0.81	0.92

	FPD size (inch)	19
C-arm CT**	Voltage (kV)	120
	Current (mA)	218
	KAP*** (Gy cm^2 / scan)	7.34

*Measured at the patient entrance reference point
**Dose indicated by the angio system
***Kerma area product

Table 4　Result of the spine surgery

Contents	Mean ± SD* (n=32)
Fluoroscopy time (min)	2.8 ± 2.5
Single shot (times)	5.3 ± 3.5
KAP (Gy cm^2)	27.6 ± 37.2
C-arm CT (times)	2.3 ± 1.5

*SD: standard deviation

3-3. Clinical cases

The following clinical cases present the effectiveness of using the Hybrid OR.

Case 1: Refixation surgery (Fig. 4)

Reoperation was performed due to pedicle screw loosening. In the C-arm CT transverse image, the pedicle screw was inserted from the outside more than the usual procedure. In the coronal image, the hole after screw removal can also be seen inside the newly inserted screw (⇧). The C-arm CT was used to maintain safety procedures in complex bone structures.

Case 2: Pedicle screw protrusion into the spinal cord (Fig. 5)

The pedicle screw was protruding into the spinal cord (⇧). Using the C-arm CT, the sur-

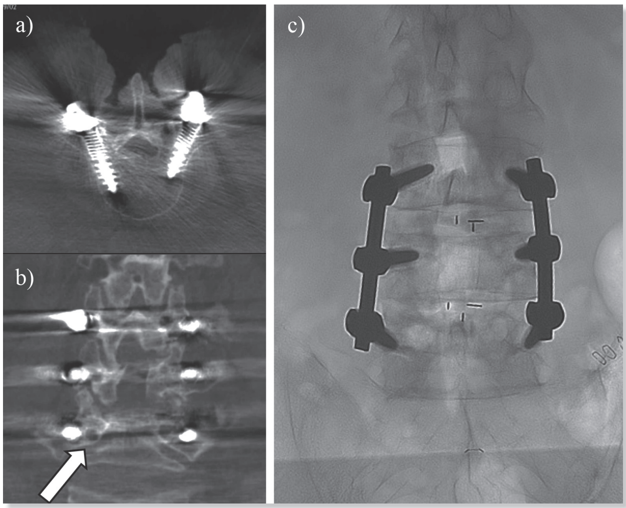

Fig. 4 Case 1: Re-operation due to loosening of the pedicle screw
a) C-arm CT image (Axial)
b) C-arm CT image (Coronal)
c) X-ray image (Post procedure)

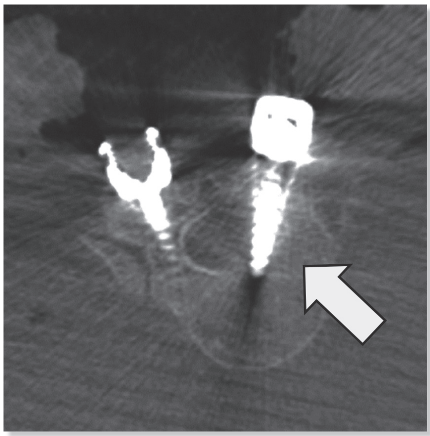

Fig. 5 Case 2: Protrusion of the screw into the vertebral foramen (C-arm CT image)

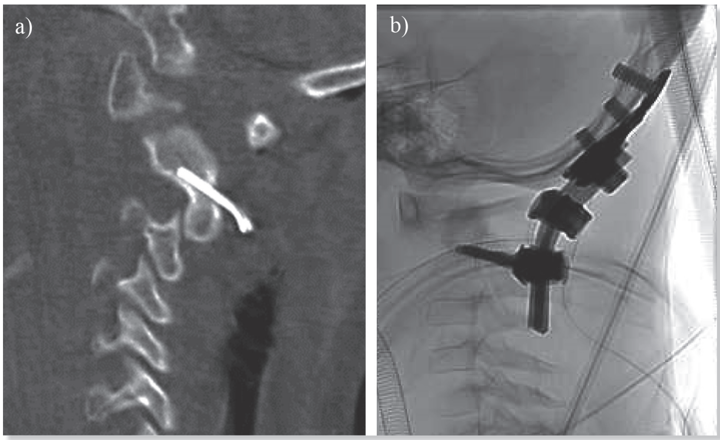

Fig. 6 Case 3: Spine surgery in small structure
a) C-arm CT image (Sagittal)
b) X-ray image (Post procedure)

geon quickly checked the patient condition intraoperatively. Moreover, understanding the risk of various complications is very important for the safety the surgery.

Case 3: Spinal fusion surgery in a child (**Fig. 6**)

This is the case of a 6-year-old child who underwent atlantoaxial fixation surgery. The procedure was performed safely even in a patient with small bone structures. In the sagittal image, the implant was inserted along the vertebral arch.

4. Discussion

In spinal surgery, a mobile fluoroscope system with an image intensifier (I.I.) is commonly used. However, this system has some limitations, particularly because of its small imaging field and nonuniformity between the central and peripheral areas and image distortion in the peripheral area. On the other hand, the angiography system equipped with the large-imaging field FPD can improve various limitations of the mobile fluoroscopic system and can eas-

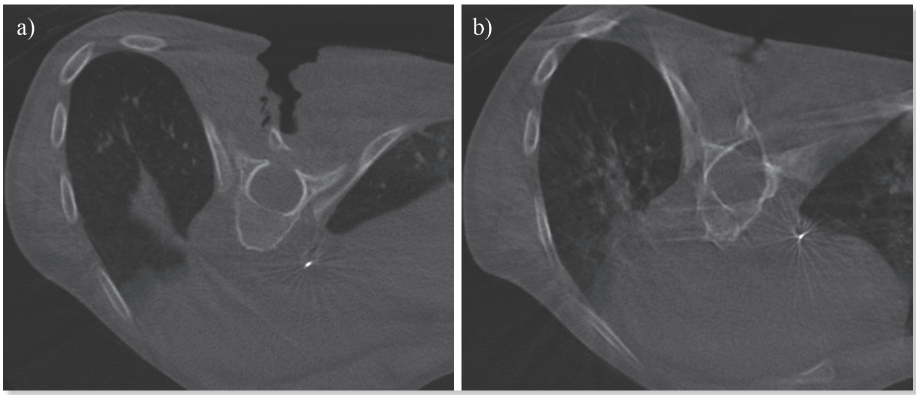

Fig. 7　Breathing control

a) With ventilation control
b) Without ventilation control

ily obtain clear no-distortion images with low radiation dose of good temporal resolution [10]. In addition, an environment that facilitates quick performance of imaging with the C-arm CT in the operating room is greatly advantageous because using volume data of the C-arm CT with great spatial resolution can appropriately support the spinal fusion surgery. Furthermore, in the recent years, navigation can be performed using volume data acquired during surgery [11, 12]. Therefore, utilization of these volume data will advance and expand in the near future.

Hybrid surgeries needed the same quality support as with the interventional radiology by radiologic technologists [13, 14]. In particularly, in the spine fusion surgery, cooperation with anesthesiologists and efforts for radiation dose reduction were essential. The image quality can be improved by preventing respiratory arrest while performing C-arm CT and digital subtraction angiography (Fig. 7).

The scattered radiation distributions of fluoroscopy or imaging dose and C-arm CT imaging dose are completely different. In the C-arm CT where X-ray tube rotates around the body, the radiation is widely distributed in the direction perpendicular to the rotation axis and does not spread so much in the body axis direction [15]. In particular, the scattered radiation to the foot side direction is shielded by the operation table and base. A management planning to protect the medical staff from radiation exposure should be included because of the scattered radiation distributions during the C-arm CT procedure, in addition to the fluoroscopy and single shot.

5. Conclusion

In this report, examples of Hybrid OR utilization for spinal fusion surgeries were reported. With minimally invasive treatment, which often involves surgical field restrictions, the use of imaging diagnostic equipment during surgery is expected.

A Hybrid OR is also useful in spinal fusion surgery and is one of the indispensable equipment to safely and reliably perform various surgeries, including those in the bones and joints.

6. Acknowledgment

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Development and Techniques of Using a Fixation Device for Radiographic Imaging

Keigo Arita[1), Yoshinori Takao[1), Kenji Kishimoto[1), Masanobu Narasawa[1), Minoru Hosogai[2), Haruka Babano[1), Yuji Sakai[1), Mai Ishibashi[1), Takao Ichida[1)

1) Department of Radiology, Osaka City University Hospital: Radiological Technologist
2) Department of Radiology (Retirement), Osaka City University Hospital: Radiological Technologist

Key words: fixation device, radiographic imaging, positioning, safety procedure

【Summary】
Radiographic imaging is one of the conventional imaging methods that is widely used to diagnose diseases and evaluate patients' response to treatment. Therefore, proper patient and equipment positioning should be established during an X-ray examination, which could otherwise produce inadequate X-ray images. Hence, we developed a fixation device to improve positioning. This report aims to explain the specifications and techniques of using a self-made fixation device.

The fixation device is made of closed-cell polyethylene foam that has an L-shaped convex part at the vertical portion and a 2.7 kg Pb block placed at the bottom portion for more stability.

The effect of using the fixation device was dramatical as proper positioning was easily achieved and maintained during X-ray examination. Thus, the fixation device should be used while performing radiographic imaging procedures.

Introduction

Several imaging methods pertaining to the importance of proper positioning during an X-ray examination have been previously published[1, 2)], but it is difficult to accurately reproduce them because of the patient's condition and X-ray imaging situations. Relieving and minimizing the patient's muscle tension are advisable in radiographic imaging[3)]. In fact, we frequently encounter patients who are unable to maintain a certain position during an X-ray examination even for a short period of time. X-ray examinations of the head and neck and extremities are often difficult to perform because patients tend to be nervous and extremely conscious in trying to maintain their position, which eventually causes unintentional body movements.

An X-ray examination performed in an unnatural position increases the physical burden on the patient and makes it difficult to establish a proper position.

Fixation devices for radiographic imaging have previously been used to improve various problems caused by motion, without causing pain to the examinee, and enhance the quality of radiographic images[4-7)]. Currently, several fixation devices used are made of lightweight materials such as expanded polystyrene and urethane resin. These are designed to adjust and stabilize the photographic position[8-11)] but not to suppress the force in the horizontal direction, such as rotation and plantar flexion, which becomes a problem during X-ray exam-

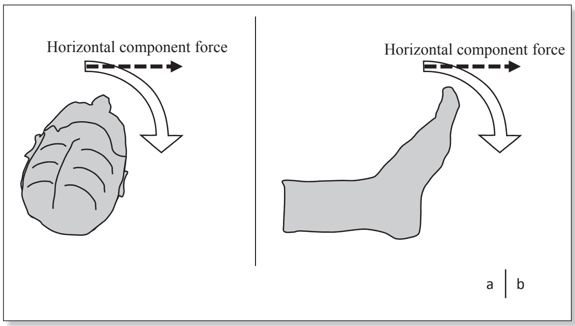


Fig.1 Problematic motions in radiographic imaging
Initial movement of rotation and plantar flexion has large horizontal component force.
a) Rotation b) Plantar flexion

ination of the head and feet (Fig.1a, b). Therefore, we developed a fixation device for radiographic imaging that enables suppression of the horizontal component force in various X-ray examinations and clinically applied.

This study reports the development and techniques of using a fixation device for radiographic imaging to improve positioning stability and promote comfort during an X-ray examination.

1. Specifications

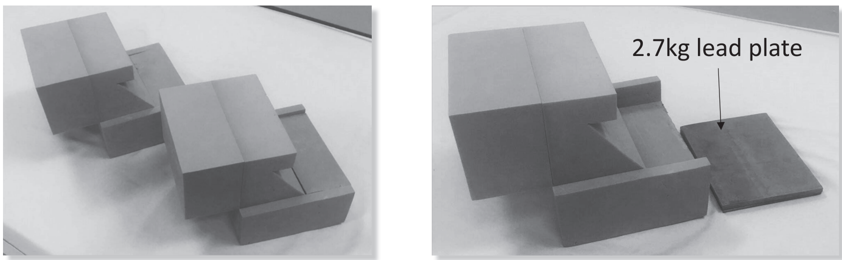
The materials and structures of the fixation device are described as follows:

1-1 Materials

The fixation device is made of closed-cell polyethylene foam with a moderate flexibility and strength and an excellent durability, which is manufactured by mixing and thermally decomposing various raw materials such as organic foaming agents. During the process, innumerable bubbles are generated inside the material and resin-like features are left. It is lightweight and has excellent durability as well as water and chemical resistance [12]. It is also designed to be extremely effective in preventing various types of contamination that can occur in medical settings, and it is not sensitive to chemicals used for cleaning. Moreover, the fine air bubbles provide softness and warmth to the patient.

1-2 Construction

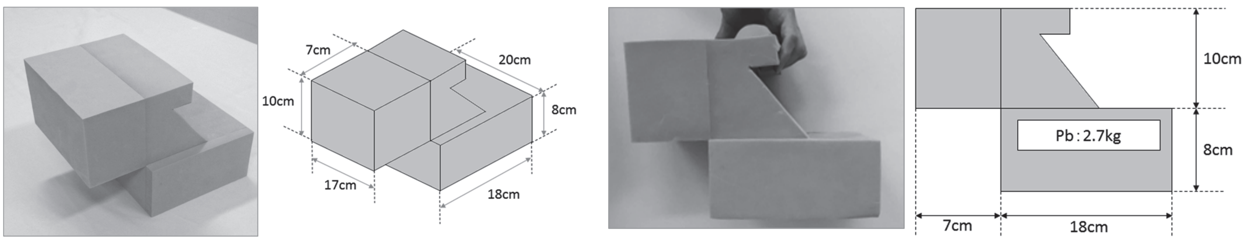
The design and shape of the fixture are shown in Fig.2a and Fig.2b. The fixation device is composed of an L-shaped pedestal with a 2.7 kg Pb block and an X-ray transmission that supports the patient. The support part is convex and is positioned 8 cm above the bottom. This is designed to not interfere with the cassette or other devices that aid in efficiently stabilizing various parts of the body. In addition, it can be easily carried because of the handle at the back. The fixation device is 20 cm in width, 25 cm in depth including the convex part, 18 cm in height, and 2.8 kg in total weight (Fig.3a, b).



a) Using two devices in the X-ray examination

b) The 2.7 kg lead plate into the fixation device

Fig.2 Fixation device for radiographic imaging



a) Exterior of the fixation device

b) Lateral side view

Fig.3 Design of the fixation device

2. How to use

The use of the fixation device in various imaging methods depends on the preferences of the radiological technologist. However, this fixation device is highly effective for radiographic imaging of the following regions: head, lateral spinal, frontal hip joint, and frontal ankle. This is because these areas require force suppression in the horizontal direction. This report also shows how to use the fixation device during X-ray examinations. Two fixation devices can simultaneously be used in one setting depending on the body area and purpose of the examination.

2-1 Radiographic imaging of the head

For radiographic imaging of the head, two fixation devices are used to stabilize the frontal position (Fig.4, 5). Stability is achieved by holding the head from both sides using two fixation devices. The Waters' method, Fueger's method, and cervical spine radiographic imaging in an open recumbent position, which are inferior in the stability than the antero-posterior and postero-anterior positions, are more effective with the use of a fixation device.

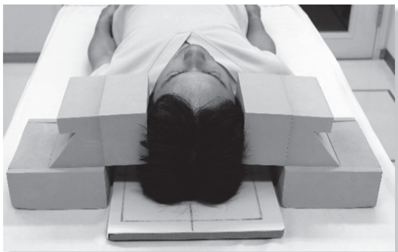


Fig.4 Anterior-posterior position of the head

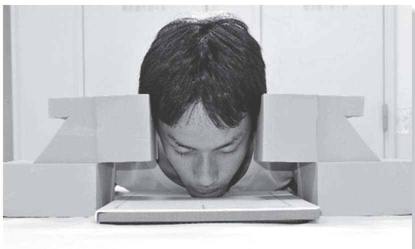


Fig.5 Waters position of the head

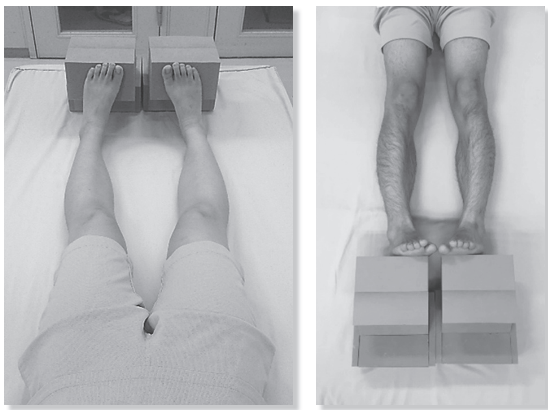
Fig.6 Lateral position of the spine

2-2 Lateral radiographic imaging of the spine

In lateral radiographic imaging of the spine, the fixation device is used to prevent body inclination (Fig.6) that is supported by the limbs. However, this position is difficult to maintain due to lack of support on the dorsal side of the body. Stability in this position is achieved by using two fixation devices to support the shoulder blades and the dorsal side of the sacrum.

2-3 Frontal radiographic imaging of the hip joint

In frontal radiographic imaging of the hip joint, the fixation device is used to maintain the inner rotation of the leg (Fig.7). Patients who undergo hip joint radiographic imaging often have muscle weakness due to aging. In addition, maintaining a position for a long time can be difficult due to postoperative pain, such as that caused by osteosynthesis or artificial joints. A stable position is achieved by using two fixation devices to support the left and right soles with inner rotation of the leg.



a) Cranial-Caudal view b) Front view

Fig.7 Anterior-posterior positon of the hip joint

2-4 Frontal radiographic imaging of the ankle joint

In frontal radiographic imaging of the ankle joint, the fixation device is used to maintain the joint in the frontal position and prevent varus (Fig.8). Stable position during this procedure is achieved by using the fixation device to support the sole that is positioned in a slight inward rotation from the reference line of the foot part. Varus can be caused by inner rotation by its own force but can be prevented by supporting the sole with the fixation device.

3. Discussion

Various devices have been previously developed and clinically applied to improve the quality of radiographic images. However, many conventional devices utilize force in a vertical direction and none have been created to suppress it. The fixation device has a fixing effect in vertical and horizontal directions because of its weight. It is highly versatile and can stabilize positions in various radiographic imaging methods. The fixation device reduces extra force exertion and promotes simple and comfortable stabilization in the photographic position for the patients. Radiologists can utilize the fixation device at ease during busy X-ray examination days. In addition, a material with several air bubbles has fine irregularities in the cross-section that generates appropriate friction. Moreover, the contact surface of the fixation device is not slippery.

Body movements are often observed when muscle weakness due to decreased momentum and suppression of the muscle output develops because of pain [13]. The cause of instability of the head is due to its spherical structure and neck muscles. Furthermore, patients are likely to move because of nonuniform distribution of the muscle mass and muscle tension of the neck in the left and right sides. On the other hand, instability in the lower limbs is due to suppression of the muscle output and muscle weakness. In such cases, the position can be maintained while reducing the burden on the joints and muscles with a slight support from the fixation device [14].

When the fixation device is effectively used, the work environment can be improved [4]. In addition, accurate radiographic imaging that is difficult to be influenced by the experiences and skills of the technician can be realized by using the fixation device correctly. Acquisition of good quality images at ease improves the inspection efficiency, but the efficiency can be reduced if the skill in using the fixation device is insufficient. Therefore, expertise in using the fixation device is important.

Furthermore, these fixation devices are effective for radiographic imaging in not only adults but also children [15]. Children are usually stressed in different environments in everyday life [16], and they cannot remain in a specific position even for a short period of time. There-

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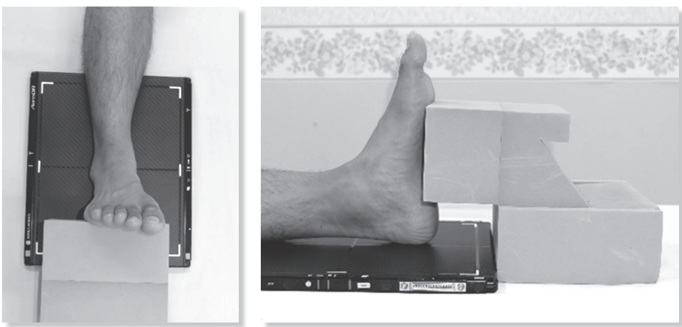

a) Front view　　b) Lateral view

Fig.8　Anterior-posterior position of the ankle joint fore, the fixation device can effectively maintain and efficiently support their posture without the support of their parents or guardians during the procedure.

The fixation device is also thought to be effective during computed tomography procedures that require long X-ray irradiation time and examination of bone mineral density (BMD). During BMD examination, the fixation device is also expected to improve reproducibility by stabilizing the inner rotation of the hip joint[17].

4. Conclusion

We report the development and techniques of using a fixation device for radiographic imaging to improve positioning stability and patient's comfort during X-ray examinations. The use of these fixation devices aims to suppress the force in various directions. In cases where stable positioning with general assistive device is difficult, the fixation device can possibly reduce the burden on the examinee and improve the accuracy of radiographic imaging.

5. Acknowledgments

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Reduction of radiation exposure in patients and cardiologists using a noise reduction technique in cardiac catheterization and percutaneous coronary intervention

Masayuki Kumashiro[1), 2)], Takahiro Kataoka[1)], Shinobu Yokota[2)], Shinobu Nakagawa[2)], Fumiaki Kiyokawa[2)], Hideki Mitsui[2)], Shinji Osumi[2)], Kiyonori Yamaoka[1)]

1) Graduate School of Health Sciences, Okayama University
2) Department of Radiological Technology, Kurashiki Central Hospital

Key words: radiation dose, noise reduction, percutaneous coronary intervention (PCI), occupational exposure

【Abstract】

We examined the effect of reducing radiation exposure in 86 patients who underwent coronary angiography and percutaneous coronary intervention before and after the introduction of an angiography system equipped with a noise reduction technique (NRT) based on an algorithm for noise reduction processing. Additionally, we examined the reduction in the occupational exposure dose over the past 5 years for 50 cardiologists. Using NRT, the incident imaging dose per frame (nGy/f) and fluoroscopic dose per pulse (nGy/p) of the flat panel detector were reduced from 120 nGy/f and 40 nGy/p to 70 nGy/f and 30 nGy/p, respectively. The dose area product (DAP) and air kerma (AK) per unit time and unit frame were calculated and compared before and after the introduction of the NRT. Significant effects of reducing the fluoroscopic dose by 26% and the imaging dose by 40% for the DAP were confirmed ($P < 0.001$). AK also showed a significant decrease of 28% ($P < 0.001$). Using the NRT, there were significant decreases in the exposure dose of cardiologists: decrease of 43% in the effective dose ($P < 0.05$) and 48% in the equivalent dose to lens of the eye ($P < 0.05$).

1. Introduction

Percutaneous coronary intervention (PCI) in patients with coronary artery disease has been an important development, but the increase in radiation exposure doses to both patients and operators is a problem in radiation protection [1-3)].

In recent years, cases of skin disorders caused by an increase in the patient exposure dose owing to prolonged fluoroscopy times and increased numbers of images were reported [4-8)].

For this reason, the International Commission on Radiological Protection (ICRP) and the U.S. Food and Drug Administration (FDA) have reported on the effectiveness of the measurement and recording of exposure doses for patients in order to prevent the occurrence of skin disorders owing to radiation [9-11)].

According to the guidelines of the Radiation Safety in the Practice of Cardiology Writing Group, PCI increases the risk of skin disorders. Thus, it is necessary to identify the safe radiation dose for PCIs. Staying below the threshold safe radiation dose is important [12)].

In recent years, development of a system to reduce radiation exposure has advanced and is being applied in clinical practice. Even in the procedure of Interventional Radiology (IVR), an angiography device equipped with a noise reduction technique (NRT) based on an algorithm for noise reduction processing (Clarity IQ) aimed at radiation exposure has been introduced and applied in clinical practice [13-14)].

Many of these reports stated that the radiation dose of patients was reduced by 50% or more [15-18)].

To apply this method, we first examined the image quality by a phantom experiment and confirmed that it is possible to reduce the incident radiation dose to the Flat Panel Detector (FPD) to 70 nGy per a frame. This was applied to clinical cases in follow-up patients after PCI.

In clinical practice, as a result of visual evaluation of the conventional image and the image after dose reduction, no significant difference was found, and we reported that it is possible to reduce the imaging dose to 40% while maintaining the image quality [19].

However, there are few reports on the exposure dose to the operators.

Swady and colleagues investigated the operator's occupational exposure dose but have not yet demonstrated a significant decrease owing to the small number of subjects and a short survey period [20].

In addition, the exposure of the operator is reduced by decreasing the radiation dose to the patient, but it is also affected by differences in the procedure and various factors related to radiation protection.

In addition, there will be a difference between target groups to be compared depending on the number of cases, fluoroscopy time, and frame number of the exposure.

In consideration of these influences, we examined a target investigation period of 5 years and examined a total of 50 cardiologists.

We investigated the number of cases of patients who underwent an examination and PCI, reviewed the transition of exposure doses before and after the introduction of the new system, and examined the transition of the occupational exposure dose of the cardiologists.

This clinical study was conducted with the approval of the Ethics Committee of Kurashiki Central Hospital, Kurashiki Central Medical Organization, Ohara Memorial Public Corporation Foundation.

2. Method

2.1 Patients

In August 2012, the angiography system (Philips Allura Xper FD 10/10, Biplane) in the third room of the cardiac catheterization laboratory (cardiac catheter room) of our hospital used the noise reduction technology (NRT) (Philips Allura Clarity FD 10/10, Biplane) equipped with an angiography device.

As follow-up after PCI at the time of introducing the new system, 86 target patients were examined for radiation exposure reduction effects of the new system by comparing the radiation dose to that of the conventional system.

The period during which inspections and PCIs were carried out on patients with conventional systems was from May 2011 to March 2014, and the period of the new system was from January 2013 to March 2014.

In addition, the group of 86 patients was composed of 74 males and 12 females of age: 74 ± 11 years old and BMI: 24.4 ± 3.1 kg/m^2. The interval between the two examinations was 11.5 ± 5.2 months.

The target examination and PCI were carried out by 30 cardiologists with more than 5 years' experience in the same period. The cardiologist did not necessarily match before and after in the survey.

Injection of the contrast medium was performed using a 5 French diagnostic catheter, in which 7 ml in total was manually injected in the left coronary artery and 5 ml in the right coronary artery.

In each case, as routine work, the LCA 8 direction, the RCA 4 direction, and the left ventriculography 2 direction angiographies were all performed in a bi-plane system, and the respective imaging directions were as follows: LCA (RAO - LAO cranial, RAO caudal - LAO, AP cranial - LAO caudal, RAO cranial - AP caudal), RCA (AP cranial - LAO, RAO caudal - LAO cranial), and LV (RAO - LAO).

A group in which cineangiography was performed using a conventional angiography apparatus was regarded as a "conventional method," and a group examined by a device equipped with a new system was taken as a "new method."

The photographing conditions of the conventional method were set as the incident dose (ID) per pulse or one frame to the flat panel detector (FPD), set in advance on the apparatus side in the maximum field of view (10 in). In the conventional method, the incident dose (IDE) to the FPD was 120 nGy/f and the perspective incident dose (IDF) was 40 nGy/p. In the new method, the IDE was 70 nGy/f , and the IDF was set to 30 nGy/p [19].

For both methods, the fluoroscopy pulse rate was set at 15 p/s, and the imaging frame rate was set at 15 f/s. In both cases, the tube voltage and tube current were given by the automatic exposure mechanism (AEC) of the biplane system.

The dose area product (DAP) in the fluoroscopy mode was DAP_F (Gy·cm^2), and DAP in the imaging mode was DAP_E (Gy·cm^2). The fluoroscopic dose per unit time (min) was the DAP_F rate (mGy·cm^2/min), and the imaging dose per unit frame (f) was the DAP_E rate (mGy·cm^2/f).

In addition, the air kerma (AK) (mGy) and AK rate (μGy/min·f) per unit time and unit frame were calculated. Since the value of each dose is part of a bi-plane system, this is the summed value of the front and side devices.

For these DAP values and AK values, the correlation between the fluoroscopy time and frame number was determined.

Incidentally, the correlation coefficient was tested using the Pearson moment correlation coefficient for a normal distribution. The non-normal distribution was performed using the Spearman rank correlation coefficient. For each calculated value, it was confirmed that it was normally distributed. This was evaluated by a paired student's t-test, and $P < 0.05$ was regarded as a significant difference.

For the DAP, the display value obtained from the area dosimeter built into each device was used. To convert the DAP to AK, we used the value obtained from the unique calculation formula incorporated in the device [21].

To measure the dose rate (mGy/min) at the patient irradiation reference point (old IVR reference point) of both systems, the reduction rate of the dose was determined and compared with the value calculated from the area dosimeter (Radcal ACCU-GOLD, USA).

2.2 Operators

From September 2012, the conventional fluoroscopic dose in our third hospital catheter room was reduced from 40 nGy/p to 30 nGy/p in the early stage, and from 120 nGy/f to 70 nGy/f for the dose [19]. From a subsequent examination, the imaging dose of the new method was set to 85 nGy/f from April 2014.

Updates were tracked from September 2014 in the fifth room, November of the same year in the ninth room, January 2015 in the second room, September of the same year in the sixth room, and in April of the same year in the seventh room. The fluoroscopic dose in all laboratories was set to 30 nGy/p, and the imaging dose was set to 85 nGy/f. Of the operators who performed coronary angiography and various IVRs (PCI, ablation, and peripheral artery IVR) in these laboratories, the following were used: the effective dose of an individual dosimeter (glass badge) of a total of 50 cardiologists (operators) trackable for 5 years from 2012 to 2016, a glass badge attached to the neck in order to ascertain the equivalent dose of the lens of the eye, the annual integrated value from January to December of the measured effective dose (mSv) for one month, and the equivalent dose (mSv) of the lens of the eye (measurement was outsourced to Chiyoda Technol, Tokyo).

The number of cases of coronary angiography, PCI, chronic total occlusion lesion (CTO), ablation, and peripheral artery IVR were obtained. Furthermore, each annual transition in the number of cases was compared with coronary angiography CT (CTCA) and coronary artery MRI (MRCA), respectively.

Since the numbers of PCIs and CTOs were included in the number of coronary angiography examinations, the total number of coronary angiography examinations, ablations, and peripheral artery IVRs was the total number. In order to exclude the influence of the total number of cases during each fiscal year, this was compared with records from 2012 according to the values obtained by dividing the average dose for each year by the total number.

In each group, the total number of 50 cardiologists compared with 2012 is 30 (age: 41 ± 13 years) in 2013 and 2014, and 27 in 2015 and 2016 (age: 42 ± 12 years old).

After confirming that this was a normal distribution, an evaluation was made by a paired student's t-test, and $P < 0.05$ was regarded as a significant difference.

Furthermore, for these 10 cardiologists (average years of experience: 15 years, maximum: 34 years, minimum: 7 years) who conducted various IVRs with an effective dose of 3 mSv or higher among these cardiologists, the effective dose and the transition of the equivalent dose of the crystalline lens of the eye were examined.

In order to exclude the effect of the number of cases of IVR during the comparison year, the total number of PCIs, ablations, and peripheral artery IVRs was taken as the total number of IVRs and compared by the average dose of each year divided by the total number of IVRs.

In addition, the annual fluoroscopic dose, imaging dose, effective dose, and reduction rate of the equivalent lens dose of the eye lens in the laboratories where dose reduction was performed in stages were compared with the respective values in 2012.

Statistical processing was performed by a Wilcoxon's rank sum test, and the median was also determined. $P < 0.05$ was considered to be a significant difference. The rate of reduction (De) and the rate of reduction of fluoroscopic dose (Df) in each year were calculated using the following equations (1) and (2), respectively:

$$De = \frac{\Sigma\ (D_1e \times M_1e + D_2e \times M_2e)}{(D_1e \times 12 \times 6)} \quad \text{——— (1)}$$

$$Df = \frac{\Sigma\ (D_1f \times M_1f + D_2f \times M_2f)}{(D_1f \times 12 \times 6)} \quad \text{——— (2)}$$

where D_1e: imaging dose of the initial stage (2012), D_2e: imaging dose after update, D_1f: fluoroscopic dose of the initial stage (2012), D_2f: updated fluoroscopic dose, M_1e: number of months of initial imaging dose, M_2e: number of months performed with the updated imaging dose, M_1f: number of months performed with the initial fluoroscopic dose, and M_2f: number of months performed with the updated perspective dose.

Note that Σ represents the total dose of all laboratories from the third room to the ninth room.

3. Results

3.1 Patient exposure dose

3.1.1 Dose contrast in conventional and new methods

The measured value of the fluoroscopic dose at the patient irradiation reference point in the conventional method was 27 mGy/min, which was consistent with the dose rate of 27 mGy/min calculated from the display value (AK) of the device. However, in the new method, the measured value was 20 mGy/min. The calculated value was 19 mGy/min (correction ratio: 1.095).

On the other hand, in the measurement of the imaging dose, the calculated value was almost equal to 173 mGy/min (ratio: 0.995) with respect to the measurement value of 174 mGy/min of the new method. However, for the calculated value of 95 mGy/min, the measured value decreased to 91 mGy/min (ratio: 0.958).

Based on the above, in the calculation of the dose reduction rate by the new method, corrections were made for the average value of 86 cases by -9.5% for the fluoroscopic dose and +3.7% for the imaging dose.

Table 1 shows the average of the fluoroscopy time (min), number of frames to be imaged (f), average of DAP and AK, and the standard edition difference for the conventional method and the new method.

The fluoroscopy time was 6.1 min in the conventional method and 5.6 min in the new method, and there was no significant difference between them ($P = 0.378$). However, with regard to the number of frames, the new method of 1651 f against the conventional method of 1740 f, and the significant difference ($P < 0.001$) was observed. For that the reason, the comparison between the two methods was evaluated by DAP_E rate and AK rate as the dose

Table 1 Average (standard deviation) of fluoroscopic time (min), number of captured frames (f), DAP, and AK in conventional method and new method.

	Reference	New	Decreasing rate (%)	*p* value
Fluoroscopic time (min)	6.1 (2.40)	5.6 (0.07)	—	0.378
Frame number (f)	1,740 (86)	1,651 (151)	—	< .001
DAP_F ($Gy\cdot cm^2$)	20.8 (0.5)	13.6 (3.7)	—	< .001
DAP_F rate ($Gy\cdot cm^2$/min)	3.49 (1.20)	2.48 (0.95)	26.4	< .001
DAP_E ($Gy\cdot cm^2$)	43.0 (23.1)	24.8 (4.0)	—	< .001
DAP_E rate ($mGy\cdot cm^2$/f)	24.5 (10.7)	15.0 (0.7)	40.3	< .001
AK (mGy)	845 (106)	533 (13)	—	< .001
AK rate (μGy/min·f)	102 (61)	73 (8)	28.4	< .001

Values are given as mean (standard deviation) or number

per unit frame.

The DAP_F rate shows a significant decrease of 2.48 $Gy\cdot cm^2$/min ($P < 0.001$) in comparison with the conventional method of 3.49 $Gy\cdot cm^2$/min. Similarly, the DAP_E rate is 24.5 $mGy\cdot cm^2$/f in the conventional method, and the new method showed a significant decrease of 15.0 $mGy\cdot cm^2$/f ($P < 0.001$). In addition, the AK rate showed a significant decrease of 73 μGy/min·f with the new method ($P < 0.001$), compared with the conventional method's value of 102 μGy/min·f.

From the above, DAP in the new method has a reduction ratio of 26.4% with a correction obtained from the measured values in the fluoroscopic mode, which almost agrees with the reduction rate of the ID per pulse (25.0%).

In the exposure mode, the reduction ratio obtained by adding the correction obtained from the actual measurement value was 40.3%, which almost agreed with the reduction rate of the ID per frame (39.9%).

3.1.2 Correlation between dose and perspective time and number of frames

Fig. 1A and Fig. 1B show the correlation between the DAP_F and perspective time of both methods. The correlation coefficients were 0.857 in the conventional method and 0.829 in

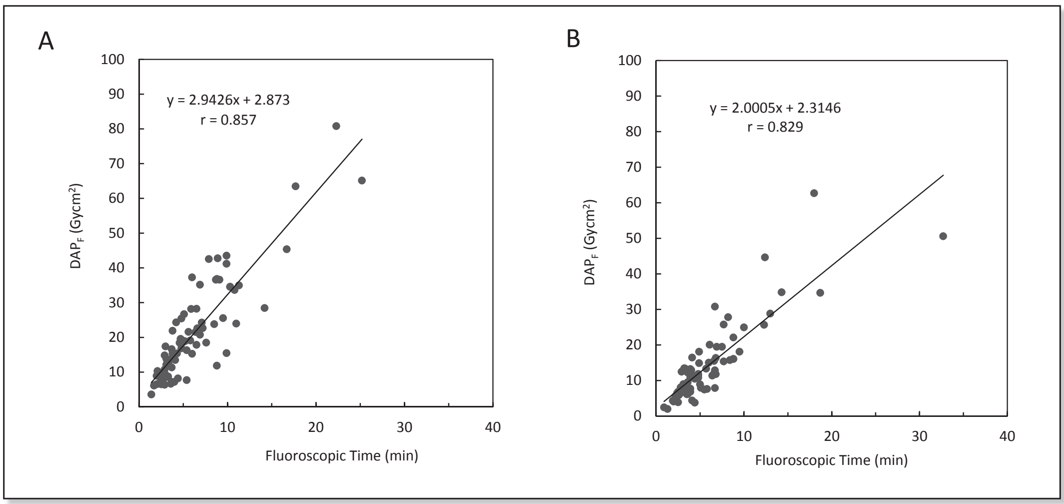

Fig. 1A Correlation between DAP_F and fluoroscopic time of conventional method.
Fig. 1B Correlation between DAP_F and fluoroscopic time of new method.

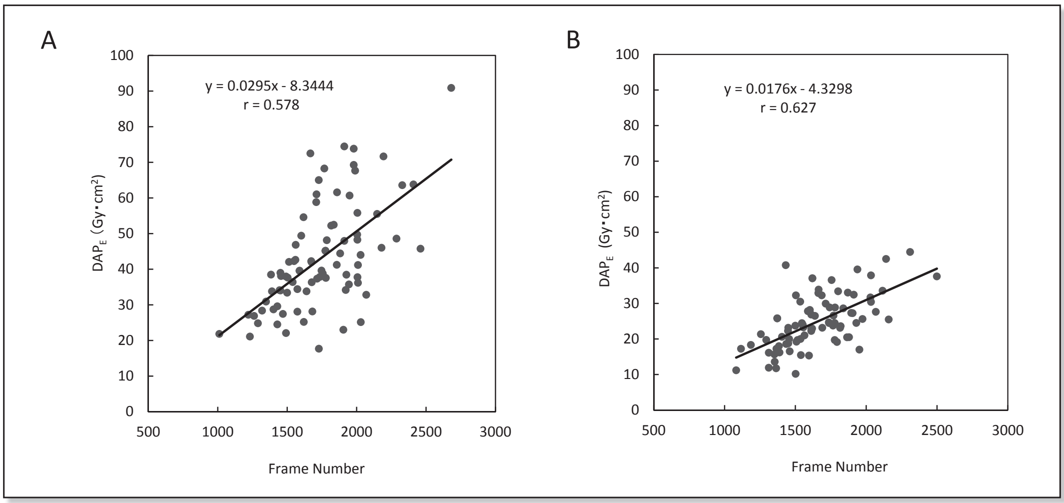

Fig. 2A Correlation between DAP_E and number of frames in conventional method.
Fig. 2B Correlation between DAP_E and number of frames in new method.

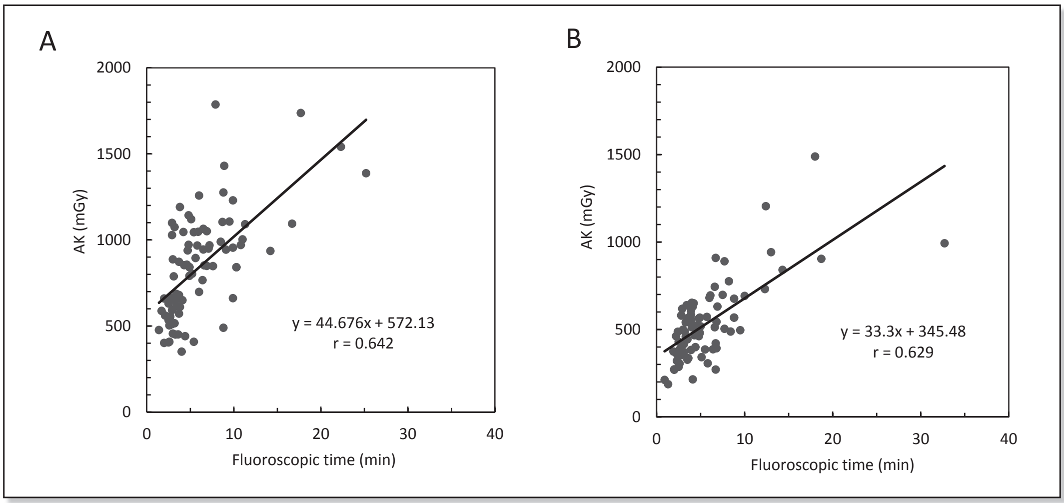

Fig. 3A Correlation between AK and fluoroscopic time in conventional method.
Fig. 3B Correlation between AK and fluoroscopic time in new method.

the new method, respectively (P < 0.001).

Fig. 2A and Fig. 2B show the correlation between the DAP_E and frame number of both methods. The correlation coefficients were found to be significantly correlated with 0.578 in the conventional method and 0.627 in the new method (P < 0.001).

Fig. 3A and Fig. 3B show the correlation between the AK and fluoroscopic time in both methods. The correlation coefficients were 0.642 in the conventional method and 0.629 in the new method, showing a significant correlation (P < 0.001).

Fig. 4A and Fig. 4B show the correlation between AK and the number of frames in both methods. The correlation coefficients were 0.639 in the conventional method and 0.561 in the new method (P < 0.001).

3.2 Operator's exposure dose

3.2.1 Trends in examinations and IVR cases

Fig. 5 and Table 2 show the coronary angiography examination number, PCI, CTO, ablation, peripheral artery IVR, CTCA, and MRCA in the past 5 years.

However, the number of PCI and CTO cases was also included in the number of coronary angiography examinations. While the number

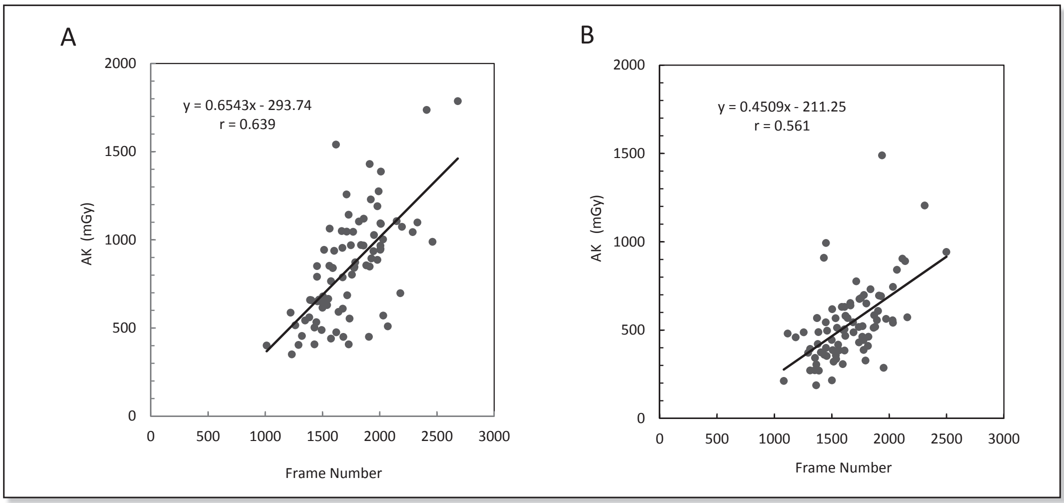

Fig. 4A Correlation between AK and number of frames in conventional method.
Fig. 4B Correlation between AK and number of frames in new method.

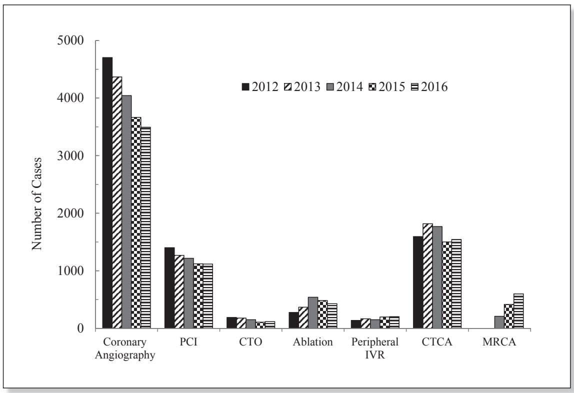

Fig. 5 Number of cases in coronary angiography examination, PCI, CTO, ablation, peripheral artery IVR, CTCA, and MRCA in past 5 years.

Table 2 Number of cases of catherization and IVR from 2012 to 2016.

	Number of Cases				
Year	2012	2013	2014	2015	2016
Coronary Angiography (PCI)	4,704 (1,401)	4,368 (1,268)	4,044 (1,217)	3,665 (1,121)	3,494 (1,117)
Ablation	276	368	541	484	429
Peripheral IVR	138	166	150	197	203
Total (All IVR)	5,118 (1,815)	4,902 (1,802)	4,735 (1,905)	4,346 (1,802)	4,126 (1,749)

All IVR : total cases of PCI, Ablation and Peripheral IVR

of PCI, IVR, and CTCA were almost unchanged, the number of coronary angiography examinations decreased from 4,704 in 2012 to 3,494 in 2016 cases, and 1210 cases were decreased compared with 2016. On the other hand, the number of MRCAs from 2014 increased to 599 cases in 2016, compensating for the decrease in the number of coronary angiography examinations.

3.2.2 Changes in exposure dose of operators

Table 3A shows the number of cardiologists engaged each year, the total number of cases, total amount of effective dose, and the average and standard deviation per cardiologist and each case.

As compared with 0.63 μSv in 2012, the average was 0.44 μSv in 2015 and 0.36 μSv in 2016 compared to 0.63 μSv, and the reduction rate in 2016 was 43% compared with 2012 ($p < 0.05$).

Similarly, Table 3B shows the total equivalent dose of the lens of the eye, and the mean and standard deviation per cardiologist and per subject.

Compared with 2.94 μSv in 2012, the averages of 1.71 μSv in 2014, 1.60 μSv in 2015, and 1.52 μSv in 2016 showed a significant decrease compared to 2012, and the reduction rate in 2016 was 48% compared to 2012 ($p < 0.05$).

Fig. 6 shows the transition of the effective dose of 10 cardiologists, and Fig. 7 shows the

Table 3A　Number of cardiologists continuously engaged from 2012, total cases, average (standard deviation) of effective dose, and average (standard deviation) of effective dose per case in each year.

Year	Number of Cardiologists	Number of Cases	Effective Dose (mSv)	p-value	Effective Dose per a Case (μSv)	p-value
2012	34	5,118	3.24 (4.31)		0.63 (0.84)	
2013	30	4,902	2.37 (3.19)	0.152	0.48 (0.65)	0.247
2014	30	4,735	2.62 (4.40)	0.192	0.55 (0.93)	0.240
2015	27	4,346	1.91 (3.42)	0.009**	0.44 (0.79)	0.020*
2016	27	4,126	1.50 (2.19)	0.014*	0.36 (0.53)	0.044*

* Shows significant difference (P < 0.05).
** Shows significant difference (P < 0.01).
Values are given as mean (standard deviation) or number

Table 3B　Number of cardiologists continuously engaged from 2012, total cases, average (standard deviation) of equivalent dose of eye lens, and average (standard deviation) of equivalent dose of eye lens per case in each year.

Year	Number of Cardiologists	Number of Cases	Mean Equivalent Dose of Eye (mSv)	p-value	Mean Equivalent Dose of Eye per a Case (μSv)	p-value
2012	34	5,118	15.02 (18.12)		2.94 (3.54)	
2013	30	4,902	11.71 (17.41)	0.097	2.39 (3.55)	0.197
2014	30	4,735	8.08 (14.67)	0.004**	1.71 (3.10)	0.010*
2015	27	4,346	6.95 (13.90)	0.003**	1.60 (3.20)	0.016*
2016	27	4,126	6.29 (9.20)	0.016*	1.52 (2.20)	0.016*

* Shows significant difference (P < 0.05).
** Shows significant difference (P < 0.01).
Values are given as mean (standard deviation) or number

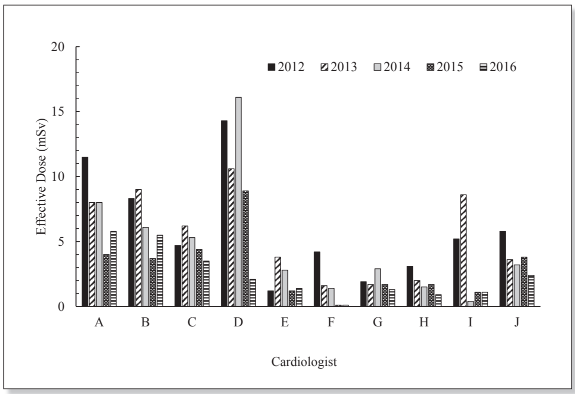

Fig. 6　Transition of effective dose for 10 cardiologists of past 5 years.

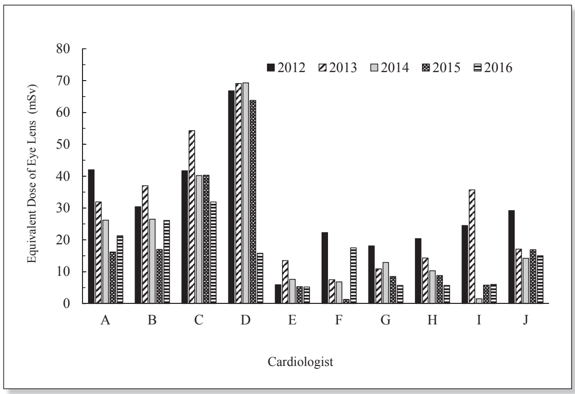

Fig. 7　Transition in equivalent dose of eye lens for 10 cardiologists of past 5 years.

transition of the equivalent dose of the eye lens.

In addition, in Tables 4A and 4B, the mean and standard deviation of the 10 cardiologists and average and standard deviation per case are shown.

The average effective dose per case was significantly reduced (1.7 μSv in 2015 and 1.4 μSv in 2016 vs. 3.3 μSv in 2012) (p < 0.01).

In addition, the average value of the equivalent dose of the lens of the eye per case significantly decreased from 16.6 μSv in 2012 to 11.3 μSv in 2014, 10.2 μSv in 2015, and 8.6 μSv in 2016 (p < 0.01).

Table 4A Average (standard deviation) of effective dose and effective dose per case for 10 cardiologists continuously engaged from 2012 to 2016.

Year	2012	2013	2014	2015	2016
Effective Dose (mSv)	6.0 (4.2)	5.5 (3.4)	4.8 (4.6)	3.1 (2.5)	2.4 (2.0)
Median (mSv)	5	5	3.1	2.7	1.8
p-value		0.492	0.105	0.009**	0.004**
Effective Dose per a Case (μSv)	3.3 (2.3)	3.1 (1.9)	2.5 (2.4)	1.7 (1.4)	1.4 (1.1)
Median (μSv)	2.7	2.8	1.6	1.5	1
p-value		0.625	0.084	0.009**	0.004**

** Shows significant difference (P < 0.01).
Values are given as mean (standard deviation) or number

Table 4B Average (standard deviation) of equivalent dose of eye lens and equivalent dose of eye lens per case for 10 cardiologists continuously engaged from 2012 to 2016.

Year	2012	2013	2014	2015	2016
Equivalent Dose of Eye (mSv)	30.1 (16.8)	29.1 (20.4)	21.6 (20.4)	18.4 (19.3)	15.0 (9.5)
Median (mSv)	26.9	24.4	13.6	12.5	15.4
p-value		0.846	0.020*	0.002**	0.002**
Equivalent Dose of Eye Lens per a Case (μSv)	16.6 (9.3)	16.2 (11.3)	11.3 (10.7)	10.2 (10.7)	8.6 (5.4)
Median (μSv)	14.8	13.6	7.1	6.9	8.8
p-value		0.846	0.006**	0.002**	0.002**

* Shows significant difference (P < 0.05).
** Shows significant difference (P < 0.01).
Values are given as mean (standard deviation) or number

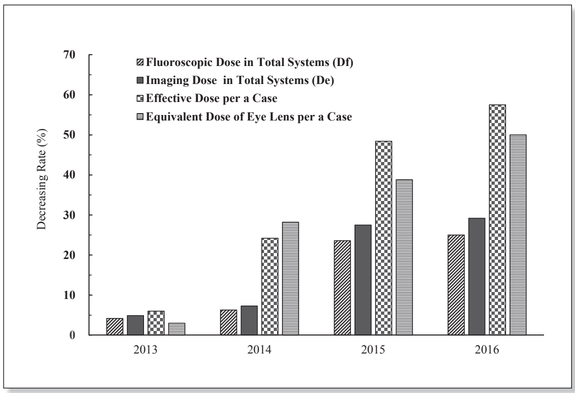

Fig. 8 Decreasing rate of fluoroscopic dose (Df) and imaging dose (De) in total system shown from 2013 to 2016 compared with 2012. By contrast, decreasing rate of effective and equivalent doses of eye lens per case are also shown from 2013 to 2016 compared with those of 2012 for 10 cardiologists.

Fig. 8 shows the transition of the fluoroscopic dose and photographing dose reduction rate of the entire laboratory every year, the effective dose per case of 10 cardiologists, and the decrease rate of the equivalent dose of the crystalline lens of the eye.

In 2016, compared to 2012, the total fluoroscopic dose in the whole laboratory could be expected to be reduced by 25% and the total imaging dose by 29.2%, but the effective dose of the cardiologists was 57.5% and the equivalent lens of the eye the dose was 48.2%, exceeding the target dose reduction rate.

4. Discussion

The measured value of our fluoroscopic dose was confirmed to be reduced to 27 mGy/min by the conventional method and 20 mGy/min by the new method. This was a 26% reduction.

The Medical Exposure Guidelines in 2006 (under DRLs of 2015) in the IVR of the Japan Association of Radiological Technologists [22] sets it to 20 mGy/min. It is assumed that an 87% tile value of the measured value was adopted by the Institutions of Japan Professional Accreditation Board of Radiological Technologists for Angiography and Intervention.

However, according to a survey of 18 angiography devices in 13 institutions by Inaba et al. [23], of those meeting the criteria of DRLs in 2015 published by the Medical Exposure Research Information Network (J-RIME) [24] and related specialized organizations in June 2016, only 5 out of 18 devices (28%) reported that the median value was also 24.4 mGy/min, exceeding 20 mGy/min. In addition, there was a discrepancy between the actual survey and the set value of DRL 2015 reporting.

Although we set the dose rate in the area to maintain the visibility of various devices in PCI, further consideration will be required on the adequacy of the set dose from the viewpoint of dose and image quality.

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In this study, we evaluated the dose reduction effect by using the DAP and AK divided by the fluoroscopy time and number of frames for patient dose assessment. Similarly, Cate et al. [16] evaluated the DAP per frame and reported that the patient's DAP (average BMI = 26.4 kg/m^2) in 39 cases was reduced from 55 to 26 $mGy·cm^2/f$: "Our results show that the patient's DAP (mean BMI = 24.4 kg/m^2) in 86 cases was reduced by about 42% from 24.5 to 15.0 $mGy·cm^2/f$." This was presumed to be owing to the difference in physiques between the Western and Japanese population.

By comparing dose values per unit time divided by the perspective time and number of frames and by the dose per unit frame, a significant correlation was confirmed between each dose, fluoroscopy time, and frame number. The comparison of DAP and AK per time and unit frame was reasonable and was assumed to be reliable for comparison.

According to the measurement results of DAP in this study, the ratio per fluoroscopic dose and imaging dose in the conventional method and the new method was almost 1:2 and was 2/3 of the total radiation dose occupied by the imaging dose. In DRLs 2015, the target dose was taken as the fluoroscopic dose rate, but in order to capture the entire exposure, it was necessary to add the imaging dose.

The new method seems to have contributed to the reduction of the dose of the entire exposure as a result of the radiation dose being reduced by about 30%. On the other hand, the International Atomic Energy Agency (IAEA) uses DAP as a reference value for the diagnostic reference level [25], and adopts clinically appropriate values.

In addition, ICRP states that the dose index of DRLs should be easily evaluable. Dosimetry that is more clinically appropriate in Japan is recommended [26-27], and it seems that setting DRLs by DAP and AK is worth considering in the future as well.

With regard to the exposure dose of the cardiologists, we evaluated this with the value divided by the number of examinations during the year, but since the exposure dose differs greatly between the examination and the IVR, it is necessary to grasp as the averaged value.

There is also a report that the radiation dose of the cardiologist is not necessarily proportional to the number of examinations, depending on protection measures such as effective use of the protective screen, distance between the detector and the subject, and distance to the patient at the moment of exposure [28]. However, qualified advice from radiological technologists on radiation protection seems to alleviate these effects.

In order to lower the exposure dose of patients and cardiologists, education and training of personnel engaged in radiation work and monitoring of protection status during the examination are necessary.

Generally, it is said that the patient exposure dose will increase by 15% by separating the detector 10 cm from the patient [29].

In addition, when the irradiation field is not narrowed, the scattered ray increases, and the radiation exposure of the patient leads to the radiation exposure of the cardiologists.

In our hospital, radiological protection was insufficient through 2012. Radiological technologists were not placed in the heart disease center except during pediatrics examinations. In 2013, we undertook organizational reforms, and radiological technologists were placed in the angiography room to assist cardiologists and cardiovascular surgeons.

We checked whether the glass badge was appropriately installed in the hybrid operating room, and that the endoscope center mainly in the cardiac catheter room. We also checked whether lead aprons, neck guards, protective eyeglasses, protective screening, etc. were defective. We also checked that the FPD was as close to the patient as possible for the cardiologist, and whether the irradiation field was narrowed.

In addition, beginning in 2013, we set the dose target value at IVR. For patients whose skin dose exceeded 3 Gy, we informed the attending physician and reported this to the in-hospital medical safety committee.

In addition, the hospital received certification as a medical radiation reduction facility accreditation facility of the Japan Association of Radiological Technologists in March 2016. In preparation for this accreditation, preparations for examinations began at the beginning of 2015. We examined data comparing the DRLs 2015 in each modality such as angiography and fluoroscopic examination [30].

DRLs 2015 was announced in June 2015, as reported in our first report to the entire hospital during the preparatory period for obtaining the certification of “Medical Exposure Reduction Facility” from the Japan Association of Radiological Technologists [31].

Furthermore, in November of the same year, data comparing DRLs 2015 in all related modalities were gathered and reported to the entire hospital as a second report.

As concrete activities, we classified the incident skin dose (ESD) into a dose category (2 to 3 Gy, 3 to 5 Gy, 5 Gy, or higher) to be exposed mainly to IVR patients every month. At 5 Gy or more, the peak skin dose (PSD) was calculated and a skin observation was conducted. This was reported to the hospital safety committee.

It was thought that these efforts affected not only the patient’s exposure dose reduction but also the awareness of the cardiologist’s protection and exposure reduction. Meanwhile, under the facility accreditation of the International Medical Safety Standard (JCI) that was accepted in 2015, the radiation safety program has been continuously strengthened. In the 6th Edition applied beginning in July 2017, we were obliged to set the target dose, dose assessment, and safety education [32]. For the next acceptance under the new standard that began in April 2016, radiation workers and other staff were given educational lectures and activities to reduce exposure.

It was estimated that these comprehensive efforts decreased as a synergistic effect with dose reduction by introducing the new system.

As a low-invasive examination method, MRCA, which was fully implemented from 2014, seems to be contributing to the reduction of catheter examinations for diagnostic purposes together with CTCA. In 2016, it was estimated that the number of coronary angiography. Although the proportion of the number of coronary angiograms in MRCA was about 17%, it was presumed that as a substitute for coronary angiography examinations, this contributed to the reduction in total radiation exposure.

In recent years, the equivalent dose limit of the lens of the eye in occupational exposure was 20 mSv over 5 years. It was proposed to lower this to a level not exceeding 50 mSv per year [33]. In our hospital, the average of 10 cardiologists declined from 30.1 mSv in 2012 to 15.0 mSv in 2016. Although this was in an area that cleared the standards, there are still cardiologists who exceed the new standard.

The possibility of overestimating monitoring with a glass badge has also been pointed out [34]. In the future, it will be necessary to establish an accurate method for measuring the exposure dose of the lens of the eye, and to wear lightweight protective glasses with less of a burden of attachment from the perspective of protection. Efforts to further reduce exposure are necessary.

5. Conclusion

We examined the radiation reduction effect of the noise reduction technique in an angiography device and found that a significant dose reduction effect of about 40% was observed for 86 patients.

In addition, we investigated the transition of exposure doses of a total of 50 cardiologists engaged in cardiac catheterization and IVR, and found a significant radiation reduction effect by noise reduction technology.

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A survey of attitudes toward breast cancer screening mammography in the Philippines

Tokiko Nakamura[1), 2)], **Kyoichi Kato**[1)], **Shoichi Suzuki**[2), 3)]

1) Showa University graduate school of Health Sciences
2) Department of Radiology, Daido Hospital
3) Faculty of Radiological Technology, School of Health Sciences, Fujita Health University

Key words: breast cancer screening, mammography, examination rate, mortality rate, Philippines

【Abstract】
In the Philippines, breast cancer is the most common type of cancer affecting women, and is the main cause of death from cancer in women. Despite this, the rate of mammogram-based breast cancer screening is low. It is likely that the rate of breast cancer screening would increase if women were more aware of its importance.

In the present study, we conducted a survey of hospital staff in the Philippines to identify the reasons for not participating in any breast cancer screening. Additionally, the staff was asked to suggest approaches to increase the screening rate, to raise public awareness about breast cancer screening using mammography, and to make breast cancer screening a regular part of medical care.

We discovered that the staff had a limited knowledge regarding breast cancer screening using mammography. Breast cancer screening is also not widely known throughout the country and most women are unaware that this examination is readily available.

Introduction

The size and number of medical institutions in countries of the Southeast Asian Region varies from country to country. In Japan, there are various types of general hospitals, such as university hospitals. Small medical facilities such as those found in Southeast Asia would not even be considered a clinic in Japan. Medical disparities exist for individuals who are unable visit well-equipped hospitals owing to various reasons in each country of the Region[1)]. Healthcare is an essential and indispensable necessity. The quality of healthcare that people receive varies depending on the country, standard of living, and environmental conditions. Therefore, we were interested in studying the efforts implemented to screen for breast cancer using mammography −a preventive medical screening method− primarily in women in Southeast Asia[2-3)].

Even in Japan, screening for breast cancer using mammography has some difficulties; these include the examination costs, physical distress such as the pain that accompanies the examination, financial burden associated with conducting a more precise thorough examination, mental distress, fear of ionizing radiation because of previous events in the country, the risk of radiation induced breast cancer, the inconvenience of going to a medical consultation, and discomfort from male staff members. Various efforts have been made in Japan to improve the examination rate, such as having an all-female staff at the examination site[4-5)]. Monetary subsidies provided by the local government also contributed to an increase in the examination rate. However, these subsidies are not common in developing countries; therefore, individuals have to pay the full cost of breast cancer screening. Among the developing countries of Southeast Asia, we focused our study on the Philippines. The Philippines is classified as a middle income country where rapid economic growth has been achieved and women's advancement in society is expected[6-7)].

In the Philippines, breast cancer is the most common type of cancer in women and is also the leading cause of death by cancer in women [8-9]. However, the rate of breast cancer screening using mammography, which has been proven to reduce mortality, is low [10]. For several years in Japan, educational activities, such as the Pink Ribbon campaign, have been conducted [11], thereby increasing awareness of breast cancer screening using mammography [12-13]. Kashiwagi et al. have shown that in the Philippines [14], women with high educational backgrounds have knowledge about the factors affecting breast cancer; however, approximately 42.7% of the population are unable to understand the factors affecting breast cancer, indicating a need for intervention from a primary education perspective. Education and effective public relations are necessary to encourage women to understand the need for a medical examination [15]. Wealthy individuals, who are able to engage in medical tourism, can seek medical services and examinations without the help of international organizations, such as the World Health Organization, or other non-governmental and non-profit organizations. Middle income earners who test positive for breast cancer following screening mammography may have the financial resources to obtain treatment, with a resulting increase in the 10-year survival rates [16-17].

We decided to investigate the level of awareness and concerns among the hospital staff, which are classified in the middle income group, regarding breast cancer screening using mammography.

1. Purpose of the Study

Breast cancer screening is important as it can detect cancer at an early treatable phase. We assumed that "medical technical staff" [18], who belong to the middle income group, do not need information about the importance of breast cancer screening making them ideal participants for the survey. The main objective of this study is to determine and clarify the reasons for not undergoing breast cancer screening using mammography. We also aim to raise the general awareness of the need for screening and to improve the rate of screening.

2. Target and Methodology

2-1. Target

2-1-1. Research Facility

St. Cabrini Hospital is a general hospital with a cancer research institute located 45-minutes from the capital city of Manila. It has 100 beds, 193 physicians, 81 nurses, 11 medical radiologists (including two women), and 8 other medical technical staff. The number of inpatient admissions for 2015 was 5,374. There were approximately 39,354 outpatient visits and approximately 1,980 mammography examinations in 2015.

2-1-2. Target for the Survey

A total of 91 female staff was considered as the target participants for the survey. We presumed that they fully understood the necessity of breast cancer screening using mammography.

2-1-3. Survey period

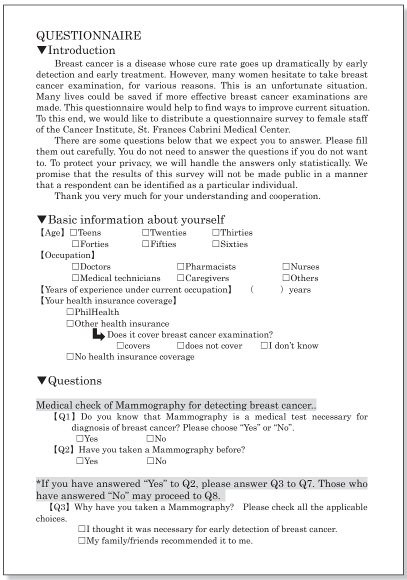
2016/03/01～2016/03/31

2-1-4. Investigation method

Questionnaire survey about breast cancer screening.

2-2. Method

We obtained consent from St. Cabrini Hospital for conducting a survey among their hospital staff. Additionally, we explained the purpose and contents of the survey to the participants before conducting the survey. The questionnaires (**Fig.1**) could be answered anonymously and were collected by mail.



QUESTIONNAIRE

▼Introduction

Breast cancer is a disease whose cure rate goes up dramatically by early detection and early treatment. However, many women hesitate to take breast cancer examination, for various reasons. This is an unfortunate situation. Many lives could be saved if more effective breast cancer examinations are made. This questionnaire would help to find ways to improve current situation. To this end, we would like to distribute a questionnaire survey to female staff of the Cancer Institute, St. Frances Cabrini Medical Center.

There are some questions below that we expect you to answer. Please fill them out carefully. You do not need to answer the questions if you do not want to. To protect your privacy, we will handle the answers only statistically. We promise that the results of this survey will not be made public in a manner that a respondent can be identified as a particular individual.

Thank you very much for your understanding and cooperation.

▼Basic information about yourself

【Age】 ☐Teens ☐Twenties ☐Thirties
☐Forties ☐Fifties ☐Sixties

【Occupation】
☐Doctors ☐Pharmacists ☐Nurses
☐Medical technicians ☐Caregivers ☐Others

【Years of experience under current occupation】 (　　) years

【Your health insurance coverage】
☐PhilHealth
☐Other health insurance
↳ Does it cover breast cancer examination?
☐covers ☐does not cover ☐I don't know
☐No health insurance coverage

▼Questions

Medical check of Mammography for detecting breast cancer..

【Q1】 Do you know that Mammography is a medical test necessary for diagnosis of breast cancer? Please choose "Yes" or "No".
☐Yes ☐No

【Q2】 Have you taken a Mammography before?
☐Yes ☐No

*If you have answered "Yes" to Q2, please answer Q3 to Q7. Those who have answered "No" may proceed to Q8.

【Q3】 Why have you taken a Mammography? Please check all the applicable choices.
☐I thought it was necessary for early detection of breast cancer.
☐My family/friends recommended it to me.

Fig.1 QUESTIONNAIRE

3. Results

Questionnaires were distributed to all 91 female staff members of the hospital. The return rate was 100%. The collected questionnaires were randomized and the summarized data was generated using Microsoft Excel. The age, occupation, and years of experience at St. Cabrini Hospital of the survey participants are shown in Table 1-1.

As the targeted participants of this survey belonged to the middle income group, physicians were excluded. We also investigated the insurance status of the participants, which is shown in Table 1-2.

Of the 91 participants, 79.1% (n=72) had PhilHealth insurance, which is 10 % higher than the rate observed in the country as a whole, whereas 6.6% were not insured. The country is currently undertaking necessary measures to establish private health insurances. Of the 72 participants mentioned above, 12 have health insurance from private companies to compensate for areas not covered by PhilHealth insurance. Among these, only half are covered for breast cancer. Below is a summary of the questions and results of the questionnaire survey (Table 1-3～Table 1-23, Fig.2).

Q1. Do you know that mammography is necessary for breast cancer detection?

The survey results showed that 69 (75.8%) of the participants knew that mammography was necessary for breast cancer detection, whereas 22 (24.2%) were unaware (Table 1-3).

Of the participants, 13 were nurses in their 20s, with 0－2 years of work experience. Of the 19 administrators who participated in the study, 7 (36.8%) responded that they were un-

Table 1-1 Classification

Age			Occupation			Years of experience		
Age	Number	Percentage (%)	Occupation	Number	Percentage (%)	Years	Number	Percentage (%)
Teens	2	2.2	Doctors	0	0.0	～1	9	9.9
Twenties	61	67.0	Pharmacists	7	7.7	1～2	8	8.8
Thirties	20	22.0	Nurses	54	59.3	2～3	12	13.2
Forties	5	5.5	Technicians	1	1.1	3～4	8	8.8
Fifties	3	3.3	Caregivers	6	6.6	4～5	6	6.6
Sixties	0	0.0	Others	19	20.9	5～	12	13.2
Unknown	0	0.0	Unknown	4	4.4	Unknown	36	39.6
Total	91	100.0	Total	91	100.0	Total	91	100.0

Table 1-2 Health Insurance status

Insurance	Number	Percentage (%)	Guarantee of PhilHealth against breast cancer		
			Guarantee	Number	Percentage (%)
PhilHealth	72	79.1			
Other	12	13.2	covers	6	50.0
Nothing	6	6.6	does not cover	5	41.7
Unknown	1	1.1	Unknown	1	8.3
Total	91	100.0	Total	12	100.0

Table 1-3 Q1;
Do you know that Mammography is a medical test necessary for diagnosis of breast cancer?

	Number	Percentage (%)
Yes	69	75.8
No	22	24.2
Unknown	0	0
Total	91	100.0

aware regarding the necessity of mammography for breast cancer screening; this was the lowest percentage observed among the different categories of participants (Table 1-4).

Q2. Have you ever received mammography examination before?

Only four (4.4%) participants answered that they have undergone mammography previously, and the rest of the 95.6% answered "I have not received it" (Table 1-5). Two were nurses in their 20s, one was a nurse in her 30s, and one was a pharmacist in her 30s (Table 1-6).

Q3. For those who answered "I have received it" in Q2, why did you have to receive mammography examination?

Two had undergone mammography as a requirement for work, one had the procedure recommended by family and acquaintances, and one had worrisome symptoms (Table 1-7).

Table 1-4 Q1; Cross tabulation of occupation and age

Q1	Pharmacists			Nurses					Technicians		Clerk				
	30's	50's	Subtotal	20's	30's	40's	50's	Subtotal	20's	Subtotal	10's	20's	30's	40's	Subtotal
Yes	6	0	6	29	8	3	1	41	1	1	0	9	3	0	12
No	0	1	1	12	1	0	0	13	0	0	2	2	2	1	7
Total	6	1	7	41	9	3	1	54	1	1	2	11	5	1	19

Q1	Caregivers			Others			Total
	20's	40's	Subtotal	20's	50's	Subtotal	
Yes	4	1	5	3	1	4	69
No	1	0	1	0	0	0	22
Total	5	1	6	3	1	4	91

Table 1-6 Q2; Cross tabulation of occupation and age

Q2	Pharmacists		Subtotal	Nurses				Subtotal
	30's	50's		20's	30's	40's	50's	
Yes	1	0	1	2	1	0	0	3
No	5	1	6	39	8	3	1	51
Total	6	1	7	41	9	3	1	54

Table 1-5 Q2;
Have you taken a Mammography before?

	Number	Percentage (%)
Yes	4	4.4
No	87	95.6
Unknown	0	0
Total	91	100.0

Table 1-7 Q3;
If you have answered "Yes" to Q2, please answer Q3: Why have you taken a Mammography?

① ☐I thought it was necessary for early detection of breast cancer.
② ☐My family/friends recommended it to me.
③ ☐I have taken Mammography before.
④ ☐I am worried of breast cancer because I have a family member who is/was a breast cancer patient.
⑤ ☐I have an anxious symptom.
⑥ ☐It is easy to take.
⑦ ☐It is safe to take.
⑧ ☐I can take it at my workplace.

Q3	1	2	3	4	5	6	7	8	Total
Number	0	1	0	0	1	0	0	2	4

Table 1-8 Q4;
If you have answered "Yes" to Q2, please answer Q4: How often have you taken Mammography?

	Number
once every six months	0
Once a year	1
Once every two years	1
Once every three years	0
More than once every three years	1
Unknown	1
Total	4

Table 1-9 Q5;
If you have answered "Yes" to Q2, please answer Q5: Have you felt any pain when you took a Mammography?

	Number
No pain	1
Tolerable	2
Intolerable	0
Unknown	1
Total	4

Table 1-10 Q6;
If you have answered "Yes" to Q2, please answer Q6: Were you embarrassed when taking a Mammography before?

	Number
No embarrassment	1
Tolerable	1
Intolerable	1
Unknown	1
Total	4

07

Q4. For those people who answered "I have received it" in Q2, what is the interval between visits for mammography examination?

Among those who had received mammography, one has the procedure performed once a year, one has it performed twice a year, one had the procedure performed only once, and the remaining person did not provide a response regarding the frequency of repeat exams (Table 1-8).

Q5. For those people who answered "I have received it" in Q2, What do you think about the "pain" (How is it?) felt during a mammography examination?

On enquiring about the pain felt during a mammography examination to the four participants who had received mammography, one had experienced no pain, whereas two people responded that they had pain but it is tolerable and one person did not respond (Table 1-9).

Q6. For those people who answered "I have received it" in Q2, Do you feel embarrassed while receiving the mammography examination?

Further, when they were asked whether the procedure was embarrassing, one person responded as "not embarrassing," one person responded as "it was embarrassing but tolerable," and one person responded as "It was embarrassing, I could not stand it." One person provided no response (Table 1-10).

Q7. For those people who answered "I have received it" in Q2, Do you have plans to have a mammography examination in the future?

For those who have received mammograms, two plan to have examinations in the future and two people provided no response (Table 1-11). This was similar to the result of Q4.

Q8. For those who answered "I have not received it" in Q2, Why haven't you received a mammography examination? (Multiple answers allowed)

41 individuals (47%) responded as "There are no symptoms and no worries," whereas 24% responded as "I heard that it hurts" and 21% responded as "It is expensive (or I cannot afford it)" (Table 1-12).

Q9. Is it embarrassing that your breast is touched during a mammography examination?

Further, 59.4% of participants stated that it

Table 1-11 Q7;
If you have answered "Yes" to Q2, please answer Q7: How do you consider Mammography in future?

	Number
Take it	2
Not take it	0
Unknown	2
Total	4

Table 1-13 Q9;
Are you embarrassed with the palpation of your mamma?

	Number	Percentage (%)
Agree	16	17.6
Slightly agree	38	41.8
Barely agree	14	15.4
Not agree	23	25.3
Total	91	100.0

Table 1-12 If you have answered "No" to Q2, please answer Q8; Why haven't you taken a Mammography?

① □I am not interested in breast cancer.
② □I have no symptoms and no anxiety.
③ □I have no breast cancer patients in my family.
④ □I think that I will not get breast cancer in my age.
⑤ □I think my physical makeup will not make me a breast cancer patient.
⑥ □It is too troublesome.
⑦ □I have no time to take it.
⑧ □I cannot take it because I have to take care of my children.
⑨ □It is too expensive to take.
⑩ □I have no chance to take it.
⑪ □I have no idea where I can take it.
⑫ □I could not take it at a facility I like to go.
⑬ □I have heard that Mammography is painful.
⑭ □I am afraid that a breast cancer could be found by the medical check.
⑮ □I will be embarrassed by a touch on my breast.
⑯ □It involves X-ray radiation, and I am scared of it.
⑰ □Others
( )

Q8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Number	15	41	25	12	7	5	13	4	19	16	1	6	21	13	5	6	14
Percentage (%)	17.2	47.1	28.7	13.8	8.0	5.7	14.9	4.6	21.8	18.4	1.1	6.9	24.1	14.9	5.7	6.9	16.1

was embarrassing that their breasts were touched during mammography (Table 1-13).

Q10. In mammography examination, is it a problem if the radiologist or technologist is a male?

67.1% responded that they considered it to be a problem if the radiologist or technician were male (Table 1-14).

Q11. Do you think mammography hurts?

Moreover, 59.4% believed that mammography hurt (Table 1-15).

Q12. Are you scared if breast cancer is detected?

58.3% were scared that breast cancer might be discovered (Table 1-16).

Q13. I am healthy and will not get breast cancer.

On the other hand, 47.3% believed that they were healthy and will not get breast cancer (Table 1-17).

Q14. Do you think that mammography costs are high?

The survey revealed that 57.2% believed that mammography costs were high (Table 1-18).

Q15. Do you think mammography examination takes a long time?

47.3% believed that the examination is time consuming (Table 1-19).

Q16. Do you think that if you visit the hospital once, you don't have to visit again?

When enquired whether they thought only one exam was necessary, 70.4% percent of

Table 1-14 Q10;
If a male Medical Radiology Technician will do the palpation for taking a Mammography, will you be in trouble?

	Number	Percentage (%)
Agree	30	33.0
Slightly agree	31	34.1
Barely agree	14	15.4
Not agree	16	17.6
Total	91	100.0

Table 1-15 Q11;
I have heard that a Mammography is painful.

	Number	Percentage (%)
Agree	24	26.4
Slightly agree	30	33.0
Barely agree	21	23.1
Not agree	15	16.5
Total	90	100.0

Table 1-16 Q12;
I am afraid that a breast cancer may be found by the medical check.

	Number	Percentage (%)
Agree	17	18.7
Slightly agree	36	39.6
Barely agree	18	19.8
Not agree	19	20.9
Total	90	100.0

Table 1-17 Q13;
I am very healthy, and will not get breast cancer.

	Number	Percentage (%)
Agree	16	17.6
Slightly agree	27	29.7
Barely agree	26	28.6
Not agree	22	24.2
Total	91	100.0

Table 1-18 Q14;
Taking a Mammography medical check is very expensive.

	Number	Percentage (%)
Agree	27	29.7
Slightly agree	25	27.5
Barely agree	17	18.7
Not agree	22	24.2
Total	91	100.0

Table 1-19 Q15;
The time of taking a Mammography could be long.

	Number	Percentage (%)
Agree	14	15.4
Slightly agree	29	31.9
Barely agree	28	30.8
Not agree	20	22.0
Total	91	100.0

Table 1-20 Q16;
Once taking a Mammography, there is no need to take it again.

	Number	Percentage (%)
Agree	7	7.7
Slightly agree	20	22.0
Barely agree	21	23.1
Not agree	43	47.3
Total	91	100.0

Table 1-21 Q17;
Are you anxious about the x-ray radiation of a Mammography?

	Number	Percentage (%)
Agree	18	19.8
Slightly agree	28	30.8
Barely agree	20	22.0
Not agree	25	27.5
Total	91	100.0

Table 1-22 Q18;
How much do you think is the reasonable rate of a Mammography?

	Number	Percentage (%)
100pesos	4	4.4
200pesos	10	11.0
300pesos	9	9.9
500pesos	19	20.9
1,000pesos	22	24.2
1,500pesos	25	27.5
Unknown	2	2.2
Total	91	100.0

participants believed that only one exam was sufficient (Table 1-20).

Q17. Are you concerned about the radiation exposure in mammography examinations?

50.6% were concerned about the radiation exposure of the procedure (Table 1-21).

Q18. How much do you think is the appropriate price or cost for a mammography examination?

When asked about what they considered as an appropriate cost for a mammography examination, 51.7% believed that the procedure should cost between 1000 and 1500 pesos, whereas 15% believed that the price should be almost 1/10th of that amount i.e., approximately 100−200 pesos (Table 1-22).

Q19. How long do you think you will actively and continuously receive mammography? What is the ideal price for you if you will regularly have a mammography examination.

On enquiring about the duration and cost that the participants considered as ideal to actively and continuously undergo mammography, 75.9% of participants considered that the appropriate price for mammography was between 500 and 1000 pesos if they were going to have the procedure on an ongoing basis, 18.5% considered approximately 1000 pesos was appropriate whereas the remaining individuals considered approximately 500 pesos was appropriate (Table 1-23).

Q20. What factors do you think makes it easy to receive a mammography examination? (Multiple answers allowed)

When asked about the factors that the participants considered would make undergoing mammography easier (Fig.2), 51.6% responded as "If the medical staff were female," 42.9% responded as "If the examination site is near the workplace," 39.6% responded as "If the ex-

Table 1-23 Q19; How much do you think is the maximum rate you are willing to pay if you want to take a Mammography actively and regularly?

Fee (peso)	Number	Percentage (%)	Fee (peso)	Number	Percentage (%)	Fee (peso)	Number	Percentage (%)
Unknown	32	35.2	1,100	0	0.0	2,100	0	0.0
100	2	2.2	1,200	1	1.1	2,200	0	0.0
200	1	1.1	1,300	0	0.0	2,300	0	0.0
300	4	4.4	1,400	0	0.0	2,400	0	0.0
400	0	0.0	1,500	3	3.3	2,500	3	3.3
500	15	16.5	1,600	0	0.0	2,600	0	0.0
600	0	0.0	1,700	0	0.0	2,700	0	0.0
700	2	2.2	1,800	0	1.1	2,800	1	1.1
800	5	5.5	1,900	0	0.0	2,900	0	0.0
900	0	0.0	2,000	5	5.5	3,000	2	2.2
1,000	15	16.5				Total	91	100.0

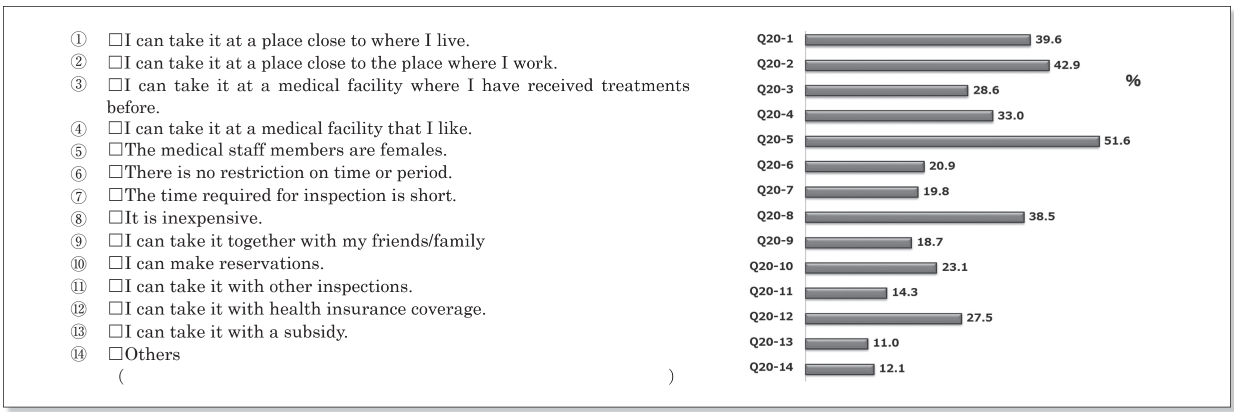


Fig.2 Q20; In which situation do you think is it easy for you to take a medical check of breast cancer?

amination site is near our residential area," 38.5% responded as "If the price of the examination is cheap," and 11% responded as "If there were subsidies for the costs of the examination."

4. Discussion

4-1. Results of the questionnaire survey

The target population of this survey was hospital staff, with as many as 75% of the participants acknowledging the need for breast cancer screening using mammography. However, very few of the participants have actually obtained a mammogram. This is most likely due to the fact that most of those surveyed are in their 20s and 30s, with some unmarried and childless. The Philippines is a family oriented culture. Some individuals in the middle income class in their 20s and 30s choose not to marry and have children at an early age to support their parents, siblings or other family members [19]. The four participants who have undergone a mammography examination are in their 20s and 30s, which is not a high risk age group for breast cancer occurrence. Reasons for obtaining the examination were various, such as a requirement for work, recommendation by family and acquaintances, or presence of worrisome symptoms. It is important that people understand that breast cancer screening is necessary, even without symptoms. In addition, the risk of breast cancer increases since the age 40 and this information is not widely known [20]. There is an overall lack of knowledge about breast cancer screening using mammography. The procedure is unfamiliar to some Filipinos in the middle income group, and mammography is not typically obtained by acquaintances of the survey participants. Despite some individuals, including the participants, are knowledgeable about breast cancer screening using mammography, they still have not undergone the examination even for preventive medical reasons. Interestingly, none of the participants replied that the reason for not undergoing mammography was not being of the appropriate age for the examination. Several participants stated that they had no worrisome symptoms and that was the reason they have not considered screening.

The cost for a mammogram at St. Cabrini Hospital is 2,300 pesos. The response, "The examination cost is high" does not seem to be because of a lack of affordability in the middle income group, which has an annual income of 250,000 – 600,000 pesos but because of others factors. The results of Q18 and Q19 seem to indicate a difference between the cost considered necessary to obtain a single mammogram and the cost considered affordable for repeat examinations. One possible reason is that the participants do not understand the true value of the examination. Question 20 revealed that although some participants undergo screening regularly and have the financial ability, they still have some other concerns when being screened. Half of the participants preferred that the medical staff in the mammography unit be female. This is a change that should be implemented to decrease the embarrassment of patients undergoing the procedure. Breast cancer screening needs to be done regularly so that the cancer can be detected at an early stage and timely treatment can be provided. Although some people understand this, they still do not undergo regular screenings. Because people assume that they do not have breast cancer, they do not actively seek out mammography. There is a gap between people's knowledge and behavior, with the result showing that they do not act as expected and cannot reasonably calculate the possible losses [21]. In addition to the absence of symptoms, there is also concern over the cost of the examination. Although some people have the financial capability, they still consider it as expensive. Additional factors such as pain and embarrassment during the procedure leads to apprehensions about undergoing mammography.

4-2. Future countermeasures and possibilities

As discussed in the previous section 4-1, there are several factors that hinder obtaining a mammogram in the middle income group of the Philippines. Factors such as lack of opportunity to undergo the procedure, pain, embarrassment, and expense observed in the present study are also applicable in Japan. Lack of knowledge and information about breast cancer and mammography is also operative. Several individuals are unaware of the high breast cancer mortality rate in the Philippines, the possibility of breast cancer at a young age, different risks of breast cancer by age, and the increase in survival rate associated with early detection. The incidence of breast cancer increases with age, with the peak incidence between 45 and 50. We highly recommended regular medical check-ups that include mammography.

Educating the public about breast cancer and the importance of screening, including self-examination, is necessary. Early treatment of breast cancer through screening mammography is better than trying to cure late stage breast cancer.

In Japan, there are those who understand the importance of breast cancer screening and can afford the expenses but still do not consult a physician. According to a survey conducted by the Japan Breast Cancer Screening Association, the burden of paying the expense personally is the main deterrent. In order to increase the examination rate, subsidies for the exam and free medical check-up coupons were provided by the local government. Simultaneously, the Pink Ribbon campaign helped in spreading awareness and understanding of the need for breast cancer screening. This helped to reduce the mortality from breast cancer. In Japan, because the local government provides subsidies and free medical check-up coupons, people consider that mammography is important as it is a priority of the local government, and this could lead to continuous or regular examinations. In the Philippines, as we found in the results from Q20, examinees do not rely on any subsidies. Subsidies for breast cancer screening may not be the priority of the local government in the Philippines, as the mortality from other diseases is considerably higher, which is common in developing countries. This would indicate that, unlike in Japan, subsidies or free coupons are not expected in the near future in the Philippines.

This survey highlighted several difficulties associated with undergoing screening mammography based on the answers of hospital staff that belonged to the middle income group. To the best of our knowledge, this is the first step in improving the breast cancer screening rate in the Philippines. Factors hindering an increase in the screening rate in the middle income group are complex. Although we now know the outlook of people toward breast cancer and mammography, certain reasons for people not undergoing mammography seem unreasonable.

5. Conclusion

In the Philippines, the potential demand for breast cancer screening using mammography is high and is necessary, but the current screening rate is low. In order to increase the screening rate, it is important for people to know basic information about breast cancer and mammography and that breast cancer screening is important for early detection and timely treatment, intermediate breast cancer discovery, and breast cancer screening based on preventive medicine. It is necessary to educate the hospital staff as well the general public regarding breast cancer screening using mammography.

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Survey of Consciousness Regarding the Acquisition of a Higher Degree and Accreditation/Professional Qualifications among Radiological Technologists and Students

Masato Mizui[1), 3)], **Yuji Mizoguchi**[1), 3)], **Hitomi Kitaoka**[2)], **Takao Tashiro**[4)]

1) Suzuka Kaisei Hospital 2) Suzuka University of Medical Science
3) Graduate School of Open University of Japan 4) Graduate School of Open University of Japan

Key words: Ph.D., Higher Degree, Radiological Technologist, Qualification

【Summary】

In recent years, many institutions have adopted 4-year programs for the education of radiological technologists. We conducted a questionnaire survey of these professionals regarding their perceptions of a higher degree and accreditation/professional qualifications. Our results indicated that 18.9% of participants wanted to obtain a higher degree. On average, 3.9 ± 2.3 years (median: 2 years) and 166.7 ± 143.4 million yen (median: 500,000 yen) were required to obtain a degree. In the questionnaire, we asked whether the participants "would like to emphasize either a degree or certification/professional qualifications." Notably, 21.6%, 1.4%, and 58.1% responded that they would like to emphasize both, the acquisition of an upper-level degree, and the acquisition of certification/professional qualifications, respectively. We conclude that radiological technologists place greater emphasis on obtaining certification/professional qualifications than on acquiring a higher degree.

Introduction

In recent years, educational institutions that train radiological technologists have shifted from a conventional 3-years program to a 4-year program in responses to advances in medical treatment, the specialization of expert technologies, and citizens' requests. In Japan, 14 public universities (e.g., national universities, universities in prefectures) and 19 private universities have been designated as training institutions by the Minister of Education, Culture, Sports, Science, and Technology. Furthermore, the Minister of Health, Labor, and Welfare has designated one vocational training school and established 12 private vocational training schools (as of 2017) [1]. These institutions produce approximately 2,000 radiological technologists each year. Due to the increased number of participating universities and decreased number of 3-year educational programs in recent years, the number of radiological technologists who acquire a bachelor's degree has increased. This era represents a transition in the tendency to acquire a bachelor's degree and the increased number of radiological technologists entering society. However, the knowledge and skills learned at each training institution do not sufficiently ensure the ability of radiological technologists to perform their work smoothly, and many such professionals gain clinical experience onsite. In addition to leveraging existing technologies used in the field, advances in radiation technology rely on the development of new technologies, which are transmitted from clinical sites every day and clinically applied.

Individuals face limits in terms of the development and dissemination of new radiological technologies, and the related methods are not academically correct. Generally, the introduction and evaluation of novel technology involves formulating a hypothesis, performing suitable experiments, presenting the findings

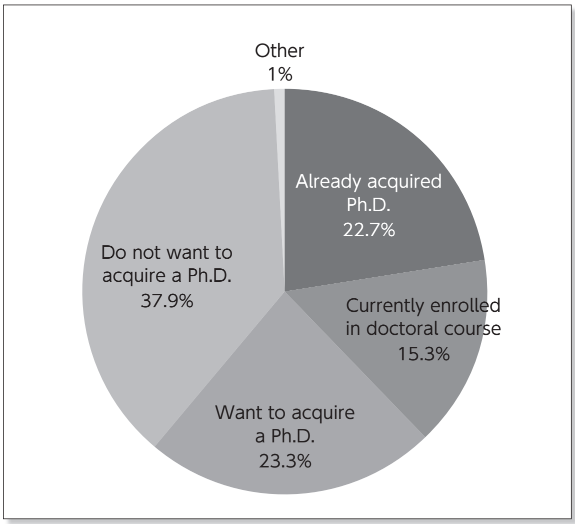

Fig. 1 Results of a survey regarding consciousness about Ph.D. acquisition among medical doctors (the graph was created using data from the Nikkei Medical Online website)

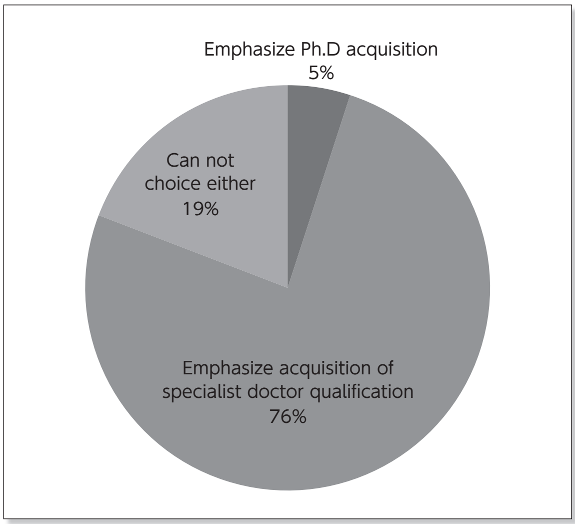

Fig. 2 Do medical doctors emphasize the acquisition of a Ph.D. or specialist doctor qualifications? (The graph was created using data from the Nikkei Medical Online website)

at scientific meetings held by relevant academic societies, and publication of the findings. However, individuals may find it difficult to acquire the techniques or methodologies needed to write conference presentations and papers. Accordingly, exposure to systematic education, especially in the context of a graduate or similar program, is desirable in terms of acquiring the methods and techniques required to write papers. For example, a physician who wishes to pursue a graduate degree (e.g., Ph.D. in medicine) belongs to the university medical institution, where he or she has the opportunity to receive such education. The same educational opportunity is often provided even when a medical doctor is transferred to another university-affiliated hospital. Some medical educational institutions may expand these opportunities by establishing Ph.D. programs including daytime and nighttime courses that can be completed even during the 6-year medical residency period [2].

In another environment, one can acquire accredited physician/specialist qualifications with the intent to master the specialized skills held by a physician. Fig. 1 presents a survey regarding consciousness about the acquisition of a Ph.D., (doctor [medicine]), which was conducted in 2011 via an online questionnaire. Fig. 2 presents a survey of consciousness regarding the emphasis on specialists and degrees [3]. This figure demonstrates that more than 60% of medical doctors are interested in or have already acquired a doctorate. Particularly, 23% of medical doctor had already obtained a Ph.D. (medicine). However, when asked a question regarding the importance of the Ph.D. or professional qualification, many medical doctors responded overwhelmingly that professional qualifications are important. This tendency has also been observed in many other studies of medical doctors [4) 5]. Possibly, this result can be attributed to the nature of a medical professional qualification as essential to medical doctor who is employed by a medical institution that provides professional medical care in a clinical setting. Still, this finding does not neglect the perceived importance of degree acquisition, as more than 60% of medical doctors are interested in acquiring a degree. In other words, many medical doctors acknowledge the importance of acquiring a degree and express interest in pursuing such education, even while considering that the necessity and utility of their work better prioritize a professional qualification than does a Ph.D. Medical schools op-

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erate on a 6-year system, and doctors who acquire higher education will receive a Ph.D. rather than a master's degree.

However, some vocational schools and universities train students to become radiological technologists. However, these schools differ in terms of the educational period (3–4 years) and types of degrees. At these institutions, radiological technologists can obtain bachelor's and associate's degrees and diplomas. A student who has acquired a diploma or associate's degree would next receive a bachelor's or master's degree, followed by the highest-ranking Ph.D. Furthermore, in Japan, a doctoral (Ph.D.) dissertation course that does not involve a doctorate program is available, but there is a contraction tendency and this cannot be described as a general means of acquiring this degree. In addition, the eligibility requirement for an examination may be questioned when a radiological technologist seeks accreditation/professional qualifications; however, no degree is required in many cases. As a medical doctor does not need to obtain a doctorate to become a specialist, a radiological technologist does not require a degree to acquire a certification/professional qualification.

In this study, we conducted a questionnaire survey that compared qualifications and professional qualifications to determine the perceptions of radiological technologists and students regarding the requirement for a higher degree to enable career advancement.

Methods

We conducted a questionnaire survey of radiological technologists and students participating in Mie Lung CT Technical Conference, held at Suzuka University of Medical Science on July 4, 2015.

In the questionnaire, we first asked about the age and sex of the respondent, as well as the degree acquired (or to be acquired).

Next, we asked "Do you want a higher degree than you acquired?" The respondent was then requested to select one of the following responses: "Strongly want," "Want," "Cannot say either," "Do not want," or "Do not want at all."

Subsequently, we asked "Do you place importance on degrees or certifications?" The respondents were asked to select one of the following responses: "emphasize acquiring a degree," "emphasize the acquisition of a certification/professional qualification," "emphasize both a degree and certification/qualification," or "neither is important."

Next, we asked the following of participants who responded positively to the first question: "Do you think that it may be possible to spend years acquiring the degree?" and "How much do you think you would pay to get the degree you want?"

The questionnaire items are listed in Table 1.

The questionnaires were completed anonymously to ensure that individuals could not be identified. They were collected after the study group ended, and submission was optional. We did not collect personally identifiable information, clarified the response data would only be used as academic material after processing, and that replies would only be accepted from those who consented to participate. Furthermore, although the content of the questionnaire question other than this question has been deleted, it is a part not related to this research.

Results

A total of 147 questionnaires were distributed, and 74 valid responses were collected (collection rate = 50.3%).

The respondents included 41 men and 33 women; of these, 63.5% (47/74), 20.3% (15/74), 12.2% (9/74), and 4.1% (3/74) were aged 20–29, 30–39, 40–49, and 50–59 years, respectively (Fig. 3).

The respondents worked in the Mie, Gifu,

Table 1 Question contents

1	Please select your age range	20-29 y	30-39 y	40-49 y	50 y or more	
2	Please select your gender	Male		Female		
3	Please select the degree you already acquire	Student (Acquire a Bachelor's degree)				
4	Do you want a higher degree than you acquired?	Strongly want	Want	Cannot say either	Do not want	Do not want at all
5	Do you think that may be possible to spend years to acquire the degree?		Years			
6	How much do you think you can pay to get degree you want?		Yen			
	- Questions 5 and 6 asked only those who chose "strongly want" or "want" in question 4.					
7	Which do you emphasis on degrees or certifications?	Degree	Certification qualification	Both	not important both	

Aichi, Wakayama, Kyoto, and Shiga prefectures.

Regarding education levels, 39.2% (29/74), 6.8% (5/74), 5.4% (4/74), 45.9% (34/74), 2.7% (2/74), and 0.0% (0/74) of the respondents were currently working toward a bachelor's degree (i.e., university student) or held a vocational school graduate diploma, associate bachelor's degree, bachelor's degree, master's degree, or Ph.D., respectively (Fig. 4).

Regarding the questionnaire items, 2.7% (2/74), 16.2% (12/74), 21.6 % (16/74), 18.9% (14/74), and 4.1% (3/74) of the respondents selected "Strongly want," "Want," "Cannot say either," "Do not want," or "Do not want at all," respectively, in response to the item "Do you want a higher degree than you acquired?." Additionally, this question was not answered on 36.5% (27/74) of the questionnaires (Fig. 5).

Furthermore, 1.4% (1/74), 58.1% (43/74), 21.6% (16/74), and 1.4% (1/74) of the respondents selected "emphasis on acquiring a degree," "emphasize the acquisition of a certification/professional qualification," "emphasize both a degree and certification/qualification," or "neither is important," respectively, in response to the item "Do you place importance on degrees or certifications?" This question was not answered on 17.6% (13/74) of the questionnaires (Fig. 6).

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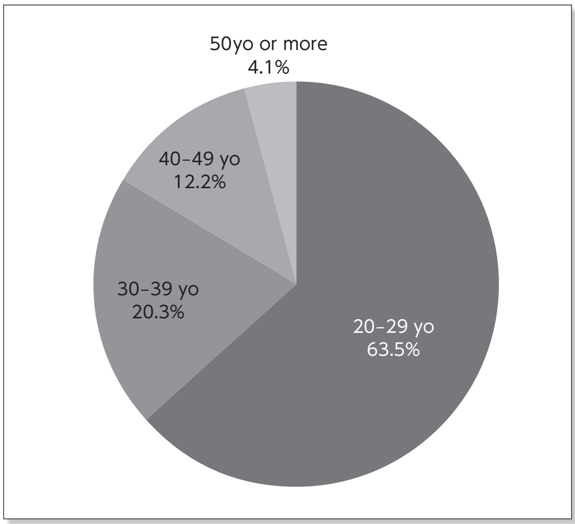

Fig. 3 Age distribution of the questionnaire respondents

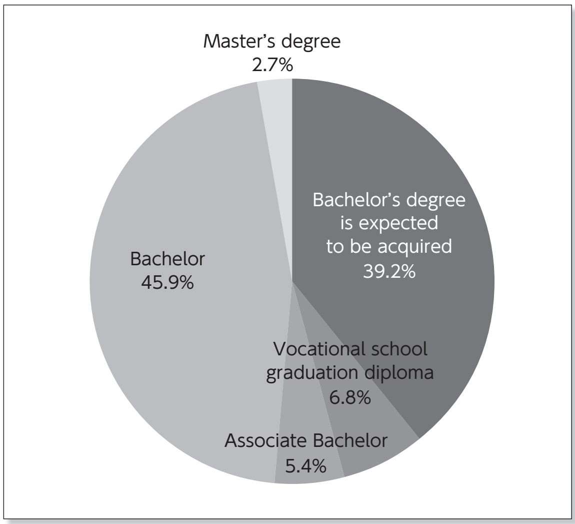

Fig. 4 Distribution of responses regarding accepted degrees

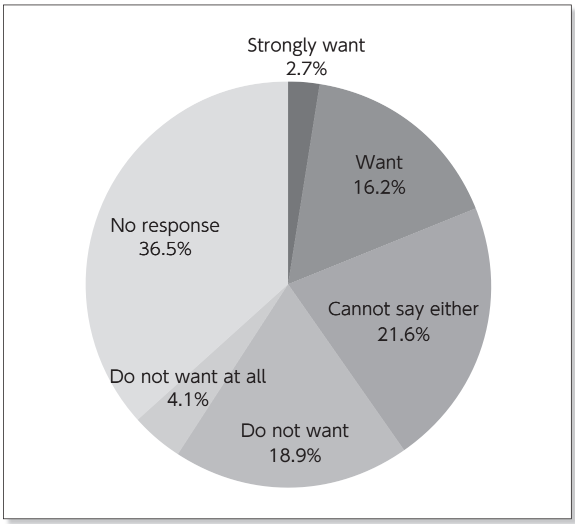

Fig. 5 Distribution of responses to the question "Do you want a higher degree than you acquired?"

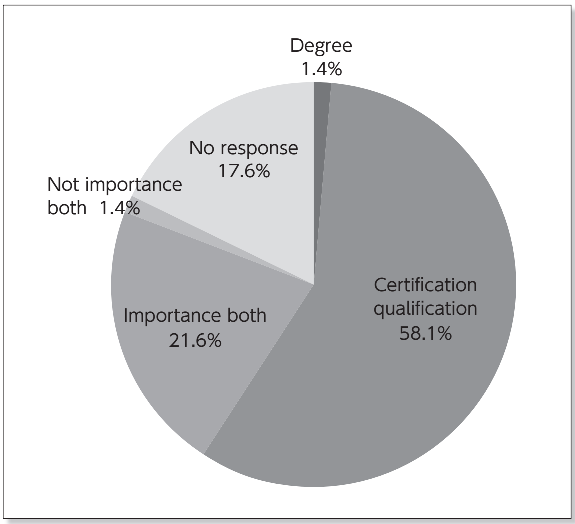

Fig. 6 Distribution of responses to the question "Do you place importance on degrees or certifications?"

As noted, the 14 participants who responded positively to the first question were asked additional questions about the perceived duration and cost required to acquire a degree. Thirteen participants responded effectively to the question "Do you think that it may be possible to spend years acquiring the degree?," with an average response of 3.9 ± 2.3 years (width 2–10 years (n=6)). Twelve participants responded effectively to the question "How much do you think you would pay to get the degree you want?" The average response was 166.7 ± 143.4

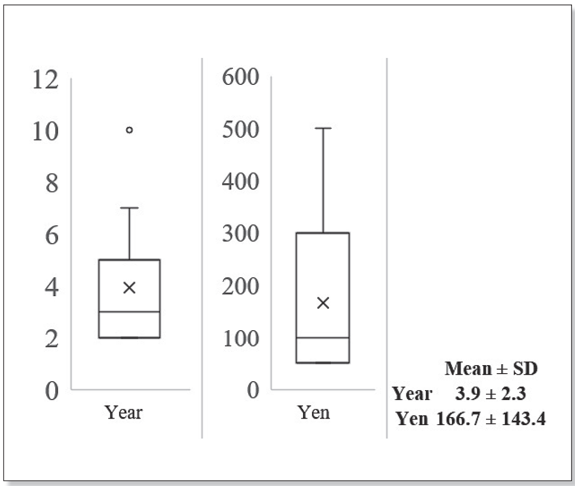

Fig. 7 Distribution of responses to the questions of "Do you think that it may be possible to spend years acquiring the degree?" and "How much do you think you would pay to get the degree you want?"

million yen (width 500,000–5,000,000 yen, median 500,000 yen (n=6)) (Fig. 7).

Discussion

The data in Fig. 2 and Fig. 5, suggest that 18.9% of radiological technologists who are currently acquiring higher degrees "Strongly want" or "Want" to acquire higher qualifications. This percentage is less than the corresponding percentage of medical doctors who completed the same questionnaire, as shown in Fig. 1. This difference is likely indicates that radiological technologists consider acquiring a higher degree less meritorious when they consider higher financial and time expenditures. Generally, the newly acquired degrees of graduates from medical institutions are not always reflected in terms of salary or promotions, except at the time of recruitment. However, 18.9% of radiological technologists wished to obtain higher degrees. This indicates a demand for advanced education among radiological technologists. According to a survey conducted by Igarashi and colleagues, 28.8% of participants already held a bachelor's degree, while 25.0% wished to acquire this degree [6]. In addition, 1.0% of participants had already acquired a master's degree, while 28.8% wished to acquire this degree. According to a survey of radiological technologists by Nakanishi et al., the ratio of radiological technologists who the ratio of radiological technologists who answered, "I would like to obtain a bachelor's degree" was 9.9%, 14.9% answered "I would like to acquire if possible", and 35.8% already obtained a bachelor's degree. In addition, the ratio of radiological technicians who answered, "I would like to obtain a master's degree" is 0.9%, 14.9% answered "I would like to acquire if possible", 4.2% have already obtained a Master's degree [7]. Although these studies used different themes and survey methods and cannot be compared directly, the results of both indicate only a small proportion of radiological technologists wish to obtain a bachelor's or master's degree.

As noted, participants in this survey responded that a higher degree would require an average of 3.9 ± 2.3 years and an average of 166.7 ± 143.4 million yen. This indicates an acceptance that after graduating from college, a bachelor's degree would require at least 2 years. In addition, even those who do not hold a bachelor's degree can obtain a master's degree if they complete the master's program after passing a pre-enrollment screening examination. Furthermore, those who already hold a bachelor's degree can complete the master's program and obtain a master's degree. Furthermore, the average monetary amount stated by respondents cannot be described as a considerably smaller burden when compared to the tuition required to continue one's education. Possibly, some respondents reported a large financial expenditure, and the small number of respondents biased the average toward a higher price. Therefore, it would seem appropriate to evaluate the median response to this question, which was 500,000 yen, or equivalent to the minimum cost (466,000 yen) necessary to complete a graduate course at the Open University of Japan, a graduate school of communication. Even in s report by Igarashi et al., 44.4% of radiological technologists replied that the economic burden made them hesitant to enter a university program. Economic support measures could effectively alleviate this burden and support the further education of radiological technologists. In a committee report, the Japanese Society of Radiological Technology indicates the importance of creating an atmosphere in which members are recommended to obtain a doctorate degree as part of their academic achievement improvement. Various measures toward this initiative have been implemented over the past decade [8].

Fig. 6 demonstrates that approximately 79% of the participants responded that they "emphasize the acquisition of a certification/professional qualification" or "emphasize both a degree and certification/qualification." Many respondents in this study indicated that they would emphasize a professional qualification, in addition to a basic radiological technologist qualification, for career improvement. By contrast, only 1.4% responded that it is only important to acquire a higher degree. This result is overwhelmingly smaller than the 58.1% of participants who responded that they "emphasize the acquisition of a certification/professional qualification." Apparently, the respondents wished to acquire a qualification, rather than a degree higher than their already completed educations. This trend is similar to that seen in the results of the medical doctor awareness survey shown in Fig. 2. However, this finding might not be generalizable, given the lack of survey respondents, the inclusion of students, or the administration of questionnaires to only those who participated in a conference in the CT area. Moreover, the "higher degree" level is not clear because the results were not aggregated by the acquired degree. Further research is needed to address these points.

In general, certifications and qualifications prove that the awardee has achieved a certain level of skill and knowledge about the field.

Degrees are given by academic institutions, such as universities, and are based on the results of research and of specific curricula intended to deepen the student's academic ability and enhance specialization[9]. The questionnaire results were reflective of the characteristics of both certifications/qualifications and degrees. In the medical field, qualified people are recognized as those qualified to do a professional job. However, a certification or qualification is not mandatory. A radiological technologist who holds a basic qualification can work in a clinical setting. A radiological technologist who holds a certification/qualification is expected to have experience in aspects of human resources and to be capable of scientifically evaluating evaluations and improving techniques, such as current photography methods and examinations of new technologies. An educational environment such as graduate school provides an optimal place to cultivate this knowledge and conduct scientific evaluations. Therefore, We suggest that it is a good way to graduate from graduate school to further specialize existing certification/professional qualifications or to create higher qualifications/professional qualifications than at present. According to a survey by Ochiai, pride is reduced "when feeling legal restrictions as a technical worker"[10]. This indicates that current radiological technologists are experiencing a deeper level of clinical expertise and feels that more advanced knowledge is necessary.

Conclusion

This study demonstrated that many radiological technologists focus on certifications/professional qualifications rather than degrees. However, some radiological technologists would also like to obtain a higher degree. These professionals may be limited by the amount of money that they can spend to obtain a degree. However, this suggests that more people would consider obtaining a higher degree if there a support plan could assist with some expenses. Few radiological technologists did not emphasize certification/professional qualifications. Many radiological technologists are not only qualified for their current work, but also want to achieve career improvement.

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Basic Characteristics of a General-purpose Semiconductor Detector for Diagnostic X-ray Measurements

Hiroshi Hamasaki, Toyoyuki Kato, Yoshiyuki Umezu

Radiological technologist, Division of Radiology, Department of Medical Technology, Kyushu University Hospital

Key words: semiconductor detector, energy response, dose response, dose rate response, directional response

【Summary】

In the present study, we aimed to evaluate the accuracy of a general-purpose semiconductor detector (Unfors Raysafe Xi, Unfors Raysafe AB) in the X-ray measurements of diagnostic areas and compare its accuracy with that of an ionization chamber dosimeter. The parameters investigated included energy, dose, dose-rate responses, directional responses, and reproducibility of the Unfors Raysafe Xi. The relative error of the Unfors Raysafe Xi with respect to energy, dose, and dose-rate responses was within 5% of the maximum. Its reproducibility was better than that of the ionization chamber dosimeter, and its direction dependance was within − 2% of the measured value from the 0° to ± 20° direction. We conclude that the Unfors Raysafe Xi is a viable and highly accurate dosimeter that can be used for X-ray measurements of diagnostic areas.

Introduction

Until now, ionization chamber dosimeters have been generally used for X-ray dosimetry in the diagnostic field. The ionization chamber dosimeter is a measuring device conforming to the definition of irradiation dose. Because it has almost no energy characteristics (dependency), it is used as a reference dosimeter for X-rays [1, 2]. However, its disadvantage is that it is susceptible to air temperature, atmospheric pressure, and humidity [3, 4].

In recent years, a simple invariance test of a diagnostic X-ray generator employing a non-connection-type X-ray output analyzer using a semiconductor detector has become common [5-7]. Semiconductor detectors do not need a warm-up period or bias voltage, which is an advantage because they are not significantly affected by temperature and pressure when compared with ionization chamber dosimeter [8]. However, the disadvantage of conventional semiconductor detectors is that their energy dependency is higher than that of ionization chamber dosimeters.[9] In addition, there are few reports evaluating the measurement accuracy of conventional semiconductor detectors.

We introduced a semiconductor type-multi-function X-ray-measuring instrument with a built-in energy correction mechanism known as the Unfors Raysafe Xi (Unfors Raysafe AB) and evaluated its accuracy in the X-ray measurements of diagnostic areas compared with that of an ionization chamber dosimeter.

Equipment

For the semiconductor detector, a Raysafe Xi detector for general photography/fluoroscopic photography was used. The X-ray high voltage device and the X-ray tube device were the DHF-155H (D) and UH-6FC-31E (inherent filtration: 1 mm Al), respectively, and the X-ray movable diaphragm used ZU-L 5 KU (inherent filtration: 1.5 mm Al).

As a reference dosimeter, we used an ionization chamber dosimeter 23344 type 0.2 cm^3 shallow chamber calibrated and connected to a

RAMTEC 1000 plus electrometer (Toyo Medic Co., Ltd.). The reference dosimeter was calibrated with soft X-rays, and the calibration energy band was 8 to 35 keV.

Raysafe Xi Specifications

The basic configuration of the Raysafe Xi dosimeter consists of the Unfors Xi base and external detectors for radiography/fluoroscopic radiography (R/F), mammography (MAM), computed tomography (CT), illuminance/luminance (Light), and scattered radiation or low level radiation (Survey); it has a multiparameter measurement function.

The R/F/MAM detector is equipped with three sensors, which are as follows: R/F high, R/F low, and MAM. In the present study we examined two sensors, R/F high and R/F low, used for the diagnosis area. R/F high is used for high dose rate measurements (20 [μGy/s] − 1000 [mGy/s]) generated without a phantom between the detector and the X-ray source, with a measurement range of 10 [μGy] − 9999 [Gy]. R/F low is used for low dose rate measurements (10 [nGy/s] − 1 [mGy/s]) generated via a phantom between the detector and the X-ray source, with a measurement range of 10 [nGy] − 9999 [Gy].

These detectors can simultaneously measure tube voltage, dose, dose rate, irradiation time, half value layer, number of pulses, pulse (frame) rate, and dose per frame in one measurement and can automatically correct measured values. By using the attached Unfors Xi View, data transfer of measurable items can be also be performed automatically.[10)]

The Raysafe Xi base unit and the R/F/MAM detector is illustrated in Figure 1.

Methods

To measure each characteristic evaluation, the R/F detector and the reference dosimeter were arranged parallel to each other in the direction orthogonal to the long axis of the X-ray tube in consideration of the heel effect. The R/F detector and the reference dosimeter were placed 3 cm from the center of the irradiation field and measured five times. It was confirmed that the side scattered ray from the R/F detector did not affect the reference dosimeter (less than 1%). To eliminate the influence of backscattering, each dosimeter was placed 60 cm from the floor and 100 cm or more from the surrounding wall (Fig. 2).

In the reference dosimeter, the absorbed dose of air (absorbed dose) D_{ic} [Gy] was obtained from the indicated value M [C/kg] by the following formula.

$$D_{ic} = W_{air} \cdot N \cdot M \cdot k_{tp} \quad (1)$$

Fig. 1 (a)

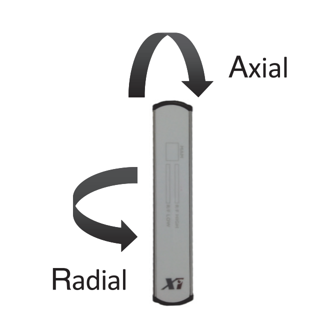


Fig. 1 (b)

Fig. 1 Overview of the Raysafe Xi.
(a) Raysafe Xi Base Unit (b) R/F detector

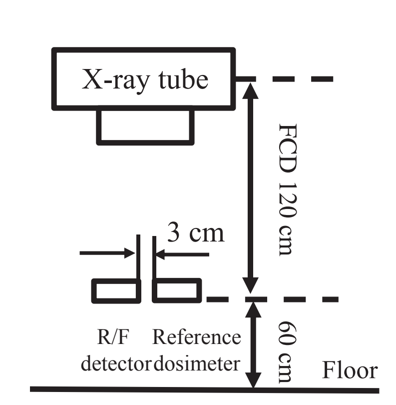


Fig. 2 Geometrical set-up for the characteristics evaluation.

W_{air}: W/e [J/C] W value of air (= 33.97 [J])
N: calibration constant of reference dosimeter at each effective energy
k_{tp}: temperature atmospheric pressure correction coefficient

Because the absorbed dose was automatically calculated by the R/F detector, the indicated value was taken as the absorbed dose D_{sd} [Gy] in the R/F detector. The relative error of the R/F detector relative to the reference dosimeter was determined.

Measurement of Effective Energy

Half-value layers at each tube voltage were measured using the aluminum attenuation method, [11, 12] and each effective energy was calculated from photon attenuation coefficient data. [13]

Using a reference dosimeter, the tube voltage was irradiated from 60 kV to 120 kV at 20 kV steps. The other irradiation conditions were set as following: the tube current was 400 mA, the irradiation time was 300 msec, the focus chamber distance (FCD) was 200 cm, and the irradiation field at the detector position was 3 × 3 cm^2.

Energy Response

FCD was 120 cm, irradiation field was at 20 × 20 cm^2 at detector position, tube voltage was changed every 20 kV from 60 kV to 120 kV, and simultaneous irradiation was carried out with the reference dosimeter and R/F detector at each tube voltage. The tube current and irradiation time were kept constant for each R/F detector setting and measurements were taken using a tube current of 200 mA and an irradiation time of 200 msec for R/F high and a tube current of 10 mA and irradiation time of 200 msec for R/F low, respectively.

Dose Response

Using the same geometrical configuration employed for measuring dose response, the tube voltage was set at 80 kV, irradiation time was varied, and simultaneous irradiation of the R/F detector and reference dosimeter was performed. For R/F high, the tube current was kept constant at 200 mA and the irradiation time was changed to 10, 20, 32, 40, 50, 100, 200, 320, 400, and 500 msec. For R/ Flow, the tube current was kept constant at 10 mA, and the irradiation time was changed to 50, 80, 100, 160, 200, 320, 400, and 500 msec.

Dose Rate Response

Simultaneous irradiation of the R/F detector and the reference dosimeter was performed by changing the tube current with the same geometrical arrangement used to measure energy response and dose response. For R/F high, the tube voltage was constant at 80 kV, the irradiation time was 100 msec, and the tube current was changed to 50, 100, 160, 200, 250, 320, 400, 500, and 630 mA. For R/F low, the tube voltage was constant at 60 kV, the irradiation time was 100 msec, and the tube current was changed to 10, 20, 32, 40, 50, and 63 mA.

Reproducibility

Simultaneous irradiation of the R/F detector and reference dosimeter was performed ten times by changing the tube voltage using the same geometrical arrangement used to measure energy response and dose response. The tube voltage was varied every 20 kV from 60 kV to 120 kV to find the variation coefficient [14] for each tube voltage. Tube current and irradiation time were kept constant for each R/F setting, and measurements were performed with a tube current of 200 mA and irradiation time of 100 msec for R/F high and a tube current of 10 mA and an irradiation time of 100 msec for R/F low.

Direction Response

Directional characteristics were investigated on the R/F detector. The angle perpendicularly incident on the detector was set to 0, and the measurement was performed by changing the angle from 0 to 350° with respect to the major axis and the minor axis at intervals of 10. The FCD was 120 cm, and the irradiation field at the detector position was 3 × 3 cm^2.

Tube voltage, tube current, and irradiation times were 80 kV, 200 mA, and 100 msec for R/F high and 60 kV, 50 mA, and 100 msec for R/F low, respectively.

Results

Measurement of Effective Energy

The effective energy at each tube voltage was 30.0, 33.5, 36.7, and 39.2 keV at 60, 80, 100, and 120 kV, respectively.

Energy Response

Table 1 shows the relative values of the R/F detector with respect to the reference dosimeter at each effective energy. The relative values of R/F high and R/F low were close to 1.0, and the relative error in the measured effective energy bands was within 1%.

Table 1 The relative ratio of the dose of the Raysafe Xi（R/F high and R/F low）for the reference dosimeter at each effective energy

	Relative ratio	
Effective energy (keV)	R/F high	R/F low
30.0	1.009	1.008
33.5	1.009	1.009
36.7	1.008	1.006
39.2	1.005	1.003

Dose Response

The results of the dose characteristics at the tube voltage of 80 kV (33.5 keV) are shown in Figure 3. The linearity of the R/F detector and the reference dosimeter was maintained against the change in dose (irradiation time). The relative error was −1.3% to 2.7% for R/F high and −1.2% to 4.0% for R/F low.

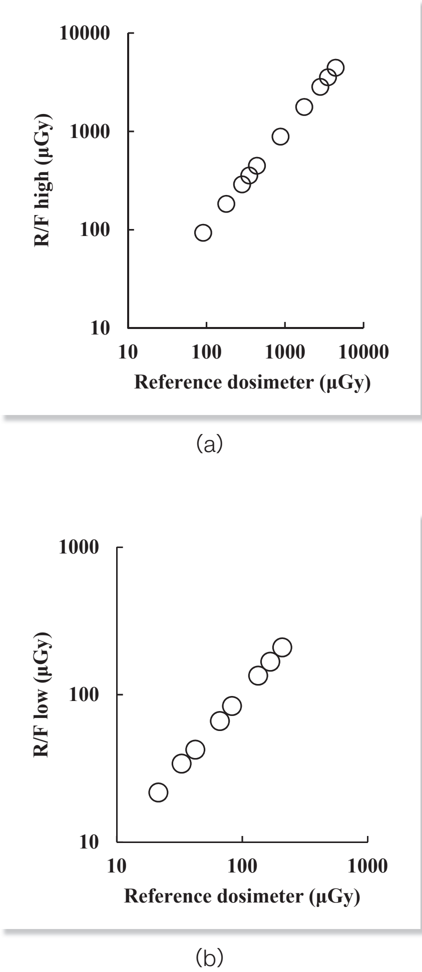


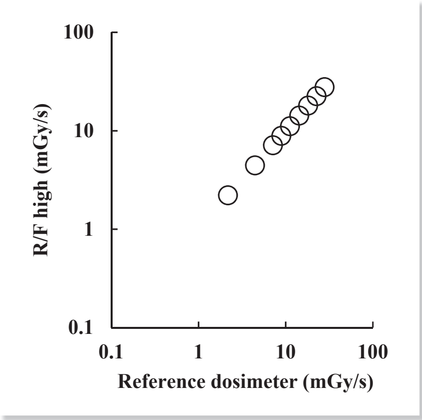
Fig. 3 Correlation between the Raysafe Xi（R/F high and R/F low）and reference dosimeter at dose（irradiation time）.
(a) R/F high (b) R/F low

Dose Rate Response

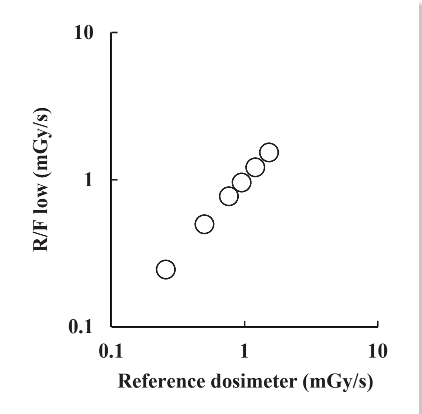
The results of the dose rate characteristics at each effective energy are shown in Figure 4. Linearity of the R/F detector and the reference dosimeter was maintained with respect to changes in tube current. The relative error was −0.8% to 0.3% for R/F high and −4.3% to 0.4% for R/F low.

Reproducibility

Table 2 shows the results of the coefficient of variation for each effective energy. For R/F high, the coefficients of variation in the reference dosimeter were from 0.001 to 0.003 and from 0.002 to 0.009, respectively. For R/F low, the coefficients of variation in the reference



(a)



(b)

Fig. 4 Correlation between the Raysafe Xi (R/F high and R/F low) and reference dosimeter at dose (dose-rate).
(a) R/F high (b) R/F low

Table 2 Coefficient of variation of the Raysafe Xi (R/F high and R/F low)
(a) R/F high, (b) R/F low

Dosimeter	Mode	Effective energy (keV)			
		30.0	33.5	36.7	39.2
Reference		0.009	0.003	0.003	0.002
R/F	high	0.003	0.002	0.003	0.001

Table 2 (a)

Dosimeter	Mode	Effective energy (keV)			
		30.0	33.5	36.7	39.2
Reference		0.066	0.049	0.063	0.064
R/F	low	0.026	0.039	0.030	0.036

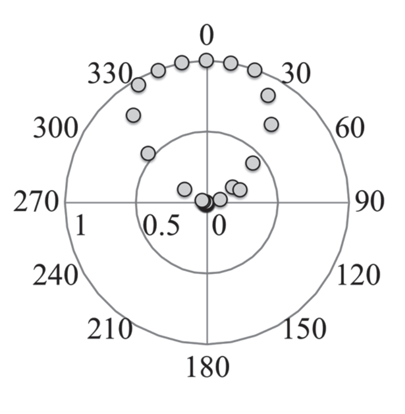
Table 2 (b)

dosimeter were from 0.026 to 0.039 and from 0.049 to 0.066, respectively.

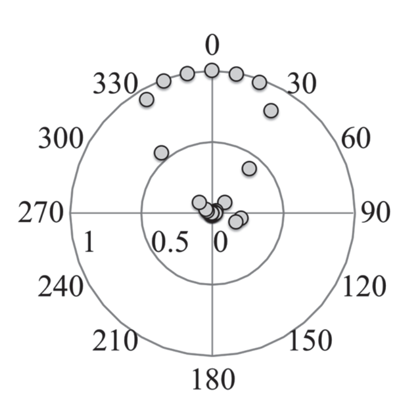
Direction Response

Since the behaviors of R/F high and R/F low with respect to the direction response were identical, the result of R/F high is shown in **Figure 5**. For ±20° in both major and minor axis directions, the result was within −2% of the measured value from 0° direction.

However, a measured value of about 20% of 0° was detected at 100° to 110° in the minor axis direction. This result suggested that the R/F detector also detected scattered rays from the back, so additional measurements were made. The R/F detector was measured in air and solid water at the same distance from 0° under the shooting conditions, but the difference between them was within 1%.



(a)



(b)

Fig. 5 Direction response of the Raysafe Xi.
(a) Axial (b) Radial

Discussion

A non-connection-type X to ray output analyzer using a semiconductor-type detector, such as the Raysafe Xi that we studied, enables data including tube voltage, dose (air kerma), half value layer, dose rate, irradiation time, output waveform, and many other types of information to be obtained. However, the semiconductor type detector has large energy dependance, leading to problems in accuracy, and an ionization chamber dosimeter with good energy response has become the reference X to ray dosimetry instrument in the diagnostic field.

In the energy response using the semiconductor detector in the present study, the relative value of the reference dosimeter showed a tendency to approach 1.0 as the energy level increased, but the relative error was within 1% at 30.0 to 39.2 keV. Because the calibration energy band of the reference dosimeter is 8 to 35 keV, results at 36.7 and 39.2 keV lacked reliability, but good results were obtained with the diagnostic area X-ray device. One reason for this is the installation of an active compensation function as part of the Unfors' proprietary technology. This function automatically judges beam energy by multiple sensors and advanced calculation processing, eliminating the need to correct kVp and dose measurement values in the diagnostic area X-ray device and mammography device. In recent years, a non-connection type X-ray measuring instrument using a semiconductor detector with or without a metal filter has been able to obtain energy information from a signal ratio multiplied with an energy correction coefficient to obtain a constant response to energy. [15-17] We believe that the same method is used in the Raysafe Xi.

The R/F detector also maintained linearity with the reference dosimeter with respect to dose response and dose rate response, with the relative error within 5% at the maximum. The coefficient of variation of the R/F detector was about 10 times as great as R/F high and R/F low, but it was 0.039 at the maximum, which was smaller than the coefficient of variation of the reference dosimeter. On the other hand, the mAs value error of the X-ray generator specified was JIS is ± (10% + 0.2 mAs). [18] Assuming that the error of the mAs value is a dose error, the dose measurement error of the Raysafe Xi was sufficiently small with respect to the dose error of the X-ray generator in the diagnostic area X-ray to consider the accuracy of the Raysafe Xi to match that of the ionization chamber dosimeter with respect to the dose measurement of the diagnostic area X-ray.

Since the direction response indicated that the R/F detector detected scattered irradiation from the back, measurement of backscattering was added, but it can be confirmed that scattering rays were seldom included even when the R/F detector was placed on the scatterer. This was thought to remove the scattered ray from the back by surrounding the back of the detector with a layer of lead 1 mm thick, but since the direct ray from the back affected the measurement value, we believe it is necessary to pay attention to the geometrical arrangement.

In addition to the functions reviewed in this study, the semiconductor type detector typically features temperature dependence and irradiation field size dependance. [19, 20] The active compensation function installed in the Raysafe XI also performs filtration and correction according to temperature, but consideration of these functions would requ1ire further study.

Conclusion

In the present study, we measured the basic characteristics of the Unfors Raysafe Xi in the X-ray diagnostic area and compared it with the ionization chamber dosimeter. The same results for were obtained for energy response, dose response, dose rate response, direction response, and reproducibility for both devices. The Unfors Raysafe Xi was thus shown to be useful for dose measurement. Moreover, unlike the ionization chamber dosimeter, it is also possible to use the Unfors Raysafe XI immediately after turning it on, it is unnecessary to correct every measurement, measurement data can be transferred to a personal computer, and operation and recording are very simple. These facts suggest that the Unfors Raysafe Xi is also useful for everyday QA/QC.

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A survey conducted by coordinated, continuing, medical staff education program (CoMSEP) graduates regarding interprofessional cooperation between radiological technologists, medical technologists, and physical therapists

Toshiya Akatsu[1), Masanori Maruyama[2), Tomoko Maruyama[3), Ryosuke Arai[4), Katsumi Miyamoto[1), Michiharu Sekimoto[5), Rumi Gotanda[6), Hiroyuki Tsushima[7), Yoshiyuki Ishimori[7), Yukari Ohashi[8), Haruhiko Ninomiya[9), Hitoshi Sato[7)

1) Department of Radiological Technology, Tsukuba Medical center Hospital
2) Department of Rehabilitation, Aida Memorial Rehabilitation Hospital
3) Social Welfare Organization Saiseikai Imperial Gift Foundation, Inc Department of Clinical Laboratory, Ryugasaki Saiseikai Hospital
4) Rehabilitation Center, Ushiku Aiwa General Hospital
5) Department of Radiological Technology, Niigata University of Health and Welfare
6) Department of Radiological Technology, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare
7) Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences
8) Department of Physical Therapy, Ibaraki Prefectural University of Health Sciences
9) Faculty of Medicine, University of Tsukuba

Key words: interprofessional cooperation, multidisciplinary collaboration, team medicine, questionnaire, radiological technologist

【Abstract】
A questionnaire survey was conducted to medical staffs working with first graduates of the Coordinated Continuing Medical Staff Education Program (CoMSEP). The target occupations were radiological technologist, medical technologist and physical therapist. Future necessity of cooperation of three job type was 81%. However, the comprehension level of job content by job type was 43% on average, and the opportunities involved with other occupations in business was 5% on average. X-ray photography, CT, and MRI were recognized by 90% of staffs in other occupations, as the specialization of radiological technologists. Moreover, they wanted to learn how to interpret these medical images. The necessity of cooperation and the requirement among professions were clarified. We were able to obtain useful information for promotion of future interprofessional cooperation.

1. Introduction

A "Report for the Promotion of Team Medicine" [1] (Ministry of Health, Labor and Welfare) describes team medicine as the medical staff that cooperate with each other to share information based on their expertise; sharing information to respond with the appropriate medical treatment for the patient. Team medicine is expected to improve the quality of medical treatment, subsequently prolonging the life of the patient, reducing the burden to the medical staff, and improving medical safety by standardizing and organizing medical treatment. For these reasons, it is necessary to improve the expertise of each of the specialties and to promote cooperation between them.

In 2014, the Ministry of Education, Culture, Sports, Science and Technology launched a "problem-solving for advanced medical personnel" training program in order to enrich the training of medical staff at the university [2]. The University of Tsukuba and the Ibaraki Prefectural University of Health Sciences have developed the Coordinated, Continuing, Medical Staff Education Program (CoMSEP), which promotes team medicine by training medical staff in strong leadership skills[3-4]. This program is mainly available as an undergraduate course for students or a certificate program for social workers who work as medical professionals. There are three main types of medical professions that this program is suited for. These are radiological technologist (RT), medical technologist (MT), and physical therapist (PT). The purpose of the certificate program is to provide the latest knowledge in the professional field, promote understanding of other medical specialties necessary for practicing team medicine, and promote dissemination of interprofessional cooperation. In this program, there are no restrictions in the choice of graduation college (vocational school), graduation year, or working hospital. The program includes e-learning (of the basic to the latest knowledge), intensive lectures, and open lectures. The program is offered throughout the year (Fig.1).

2. Purpose

Previous graduates of the CoMSEP certificate program have noticed challenges that arise in interprofessional occasions. For example, how other members of the team work and what is expected of them is not understood well enough. To this end, it is important to understand these challenges to aid interprofessional

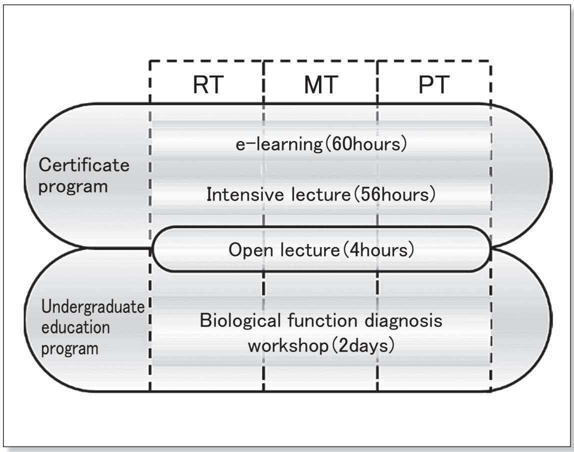

Fig.1 Scheme of CoMSEP

cooperation. Although there have been many reports of interprofessional cooperation between doctors and nurses[5-6], there are no reports of interprofessional cooperation between the three aforementioned professions, RTs, MTs, and PTs. We surveyed employees regarding interprofessional cooperation in each of these three professions, focusing on RTs.

3. Target・method

To evaluate the current state of interprofessional cooperation, an anonymous survey was conducted by CoMSEP graduates (survey period: July 1–31, 2016). The questionnaires were distributed to the three professions (RTs, MTs, and PTs in each facility) and the responses were collected. Meanwhile, radiography was written as roentgen so that other professions can easily answer. The contents of the questionnaire are shown in Table 1.

The questionnaire was divided into four categories. Questions 1 to 3 involved the personal profile of the respondents. Questions 4 and 5 were about how the respondents understood the duties and responsibilities of the other professions. Questions 6 and 7 involved how the respondents currently experienced interprofessional cooperation. Questions 8 to 10 involved the future perspectives of interprofessional cooperation. The answer format of Questions 5 and 8 was multiple choice, questions 3 and 10 required descriptive answers, and questions 6 and 7 were both multiple choice and descriptive. The responses were tallied for each job category and the results of Questions 4 and 7 were compared for RTs, MTs, and PTs and for the additional professions of doctor (Dr) and nurse (Ns).

4. Result

The total number of respondents was 627 from 11 facilities.

Within these 11 facilities, one facility con-

Table 1 Questionnaire including 10 questions regarding interprofessional cooperation

【Profile】

Q1. What is your gender?
(1. male 2. female)

Q2. What is your profession?
(1. radiological technologist 2. medical technologist 3. physical therapist)

Q3. How long is your experience in that profession?
( ) years

【About other professions】

Q4. Do you know the work contents and roles of each job category? (exclude your job category)
Dr ：(1. know well 2. know 3. do not know much 4. do not know at all)
Ns ：(1. know well 2. know 3. do not know much 4. do not know at all)
RT ：(1. know well 2. know 3. do not know much 4. do not know at all)
MT ：(1. know well 2 .know 3. do not know much 4. do not know at all)
PT ：(1. know well 2. know 3. do not know much 4. do not know at all)

Q5. Pick up from the following items what you know about the work contents of RT.
Do not pick up items you do not understand well.
1. Roentgen 2. CT 3. MRI 4. US 5. RI 6. IVR 7. RT 8. MMG 9. GI 10. Dose management

【About interprofessional cooperation】

Q6. Select three things that you think high priority about interprofessional cooperation.
1. Team approach by medical team 2. Information exchange/contact
3. Joint study group 4. Social gathering 5. Other ( )
1st ( ) 2nd ( ) 3rd ( )

Q7. How often do you cooperate with other profession in your work? (exclude your job category)
Also, write down about the contents of cooperation with other than doctors and nurses.
Dr ：(1. Quite a lot 2. Many 3. Few 4. Not at all)
Ns ：(1. Quite a lot 2. Many 3. Few 4. Not at all)
RT ：(1. Quite a lot 2. Many 3. Few 4. Not at all)
Content ( )
MT ：(1. Quite a lot 2. Many 3. Few 4. Not at all)
Content ( )
PT ：(1. Quite a lot 2. Many 3. Few 4. Not at all)
Content ( )

【Potential for interprofessional cooperation in the future】

Q8. Are there any work contents that you feel necessary for enriching interprofessional cooperation in the future?
※Items are the same as Q5

Q9. Do you feel necessity to cooperate in three professions (RT, MT, PT)?
1. Abusolutely necessary 2. necessary 3. Not much necessary 4. Not necessary at all

Q10. If you have any comments on the cooperation of three professions (RT, MT, PT), please fill in below. Theme and idea of what you want to do, what you can provide about your job category, and so on.
( )

tained up to 100 beds, two facilities had 101 to 200 beds, one facility had 201 to 300 beds, two facilities had 301 to 400 beds, three facilities had 401 to 500 beds, one facility had 501 to 600 beds, and one facility had 701 to 800 beds. In terms of the classification of each of the hospitals, one was a university hospital, one was a public general hospital, two were private general hospitals, five were general hospitals, and there were two other facilities. In the breakdown by type of medical stage were seven facilities in the acute phase, one facility in the subacute phase, two facilities in the recovery phase, and one other facility. The three job categories RT, MT, and PT were enrolled in 10 facilities. There was only one facility where PT was not enrolled.

【Profile】

Question 1 Sex

In total, 338 males (54%) and 289 females (46%) completed the questionnaires. By job category, there were 132 males (21%) and 41 females (7%) working as RTs, 66 males (10%) and 143 females (23%) working as MTs, and 140 males (22%) and 105 females (17%) working as PTs (Fig.2).

Question 2 Job category

In terms of job category, the total number of RTs was 173 (28%), of MTs was 209 (33%), and of PTs was 245 (39%) (Fig.2).

Question 3 Experience

The average length of experience for RTs, MTs, and PTs was 12 (median, 10 years), 14 (median, 11 years), and 7 (median, 5 years) years, respectively (Fig.3).

【About other professions】

Question 4 Work contents and roles of each job category

The recognition of the roles and responsibilities of Drs and Nss was 85% on average, and 0% said “I didn't know it at all.” On average, the recognition of the roles and responsibilities of the other three job categories was 43%. The recognition of the roles and responsibilities of PTs was the lowest at 31% (Fig.4).

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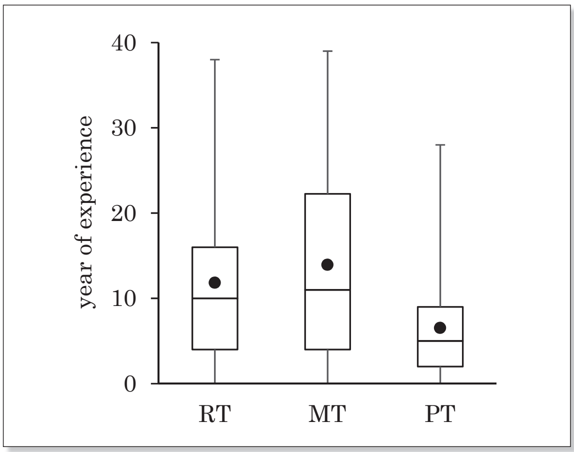

Fig.3 Distribution of the respondents’ experience

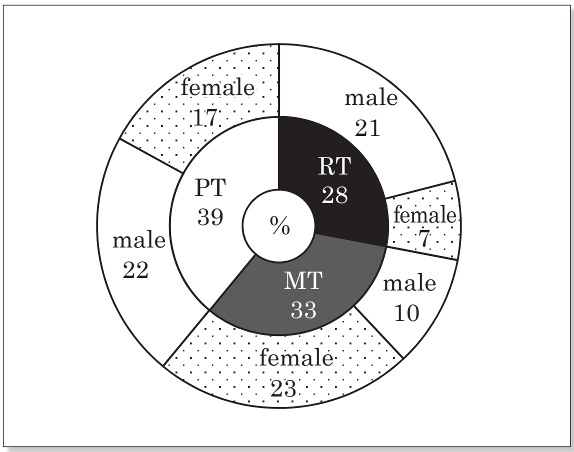

Fig.2 Breakdown of the respondents by gender

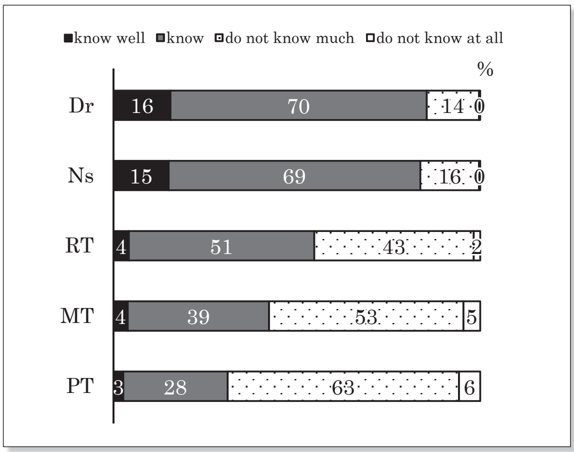

Fig.4 Recognition of each job content

Question 5　Recognition of the roles and responsibilities of RTs

The results were divided into the answers given by RTs and the answers given by the other respondents. Self-recognition of the roles and responsibilities of RTs by RTs was 89% on average. The recognition of the roles and responsibilities of RTs by the other professions was dependent upon the situation. For example, approximately 90% of the respondents recognized that radiography, CT, and MRI but less than 30% recognized gastrointestinal examination and IVR (Fig.5).

【About interprofessional cooperation】

Question 6　Priorities in interprofessional cooperation

Approximately 50% of the respondents rated "team approach by the medical team" and "information exchange/contact" as the first two priorities of interprofessional cooperation. A "joint study group" was determined as the third priority of interprofessional cooperation, at 72%. Other answers included "understanding the other profession's roles and responsibilities" and "presenting the merit of cooperation" (Fig.6).

Question 7　Opportunities to cooperate with other professions

On average, 69% of the respondents have many opportunities to meet and communicate with Drs and Nss (only 1% of the respondents mentioned that they have no opportunity). Only 5% of the respondents have many opportunities to cooperate with the three job categories. The respondents who answered that there are many opportunities to be involved with PTs was 1%, which was lower than for RTs and MTs (Fig.7). The main opportunities for cooperation with RTs was for "ultrasonic examination," "cardiac catheter examination," "consultation committee," and "observing medical images." The main opportunities for cooperation with MTs was for "ultrasonic examination," "cardiac catheter examination," "consultation

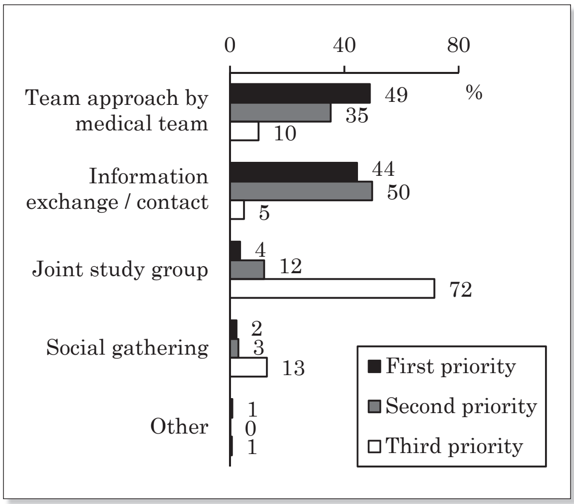

Fig.6　Priorities involved in interprofessional cooperation as determined by the questionnaire respondents

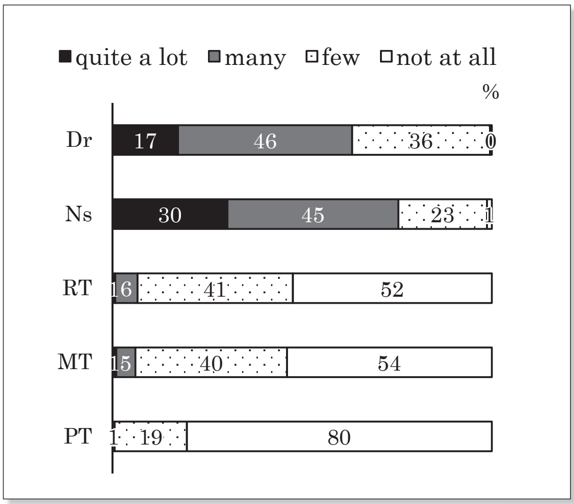

Fig.7　Opportunities of RTs, MTs, and PTs to be involved with other professions

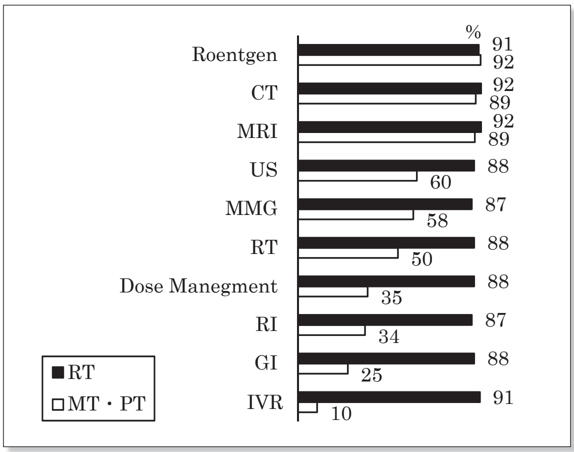

Fig.5　Recognition of RT job content

committee," and "confirmation of clinical test results." The main opportunities for cooperation with PTs was for "cardiorespiratory exercise test," "in-hospital committee activities," and "patient transfer." The number of answers that related to PTs was less than that for RTs or MTs.

【Potential for interprofessional cooperation in the future】

Question 8 Aspects of RT work requiring interprofessional cooperation

The results were divided between answers by RTs and answers by MTs and PTs. Similar to the results obtained for Question 5 (Fig.5), on average, 18% of the RTs feel necessary to cooperate with other professions in their own work. Over 50% of the respondents from the other professions mentioned that they depended on radiography, CT, and MRI for their work but dose management, nuclear medicine examination, and IVR accounted for less than 10% of their dependence (Fig.8).

Question 9 The demand for interprofessional cooperation in each of the three job categories

RTs, MTs, and PTs were questioned and 69 respondents (11%) stated that it was "absolutely necessary" for interprofessional cooperation between the three job roles, 433 (70%) stated that it was "necessary," 114 (19%) stated that it was "not very necessary," and 0 (0%) stated that it was "not necessary at all." There were 11 non-respondents (Fig.9).

Question 10 Comments describing interprofessional cooperation within the three job categories of RT, MT, and PT

Other professionals, apart from RTs, MTs and PTs, wanted to know about how interprofessional cooperation could improve anatomical identification through medical images (radiography, CT, MRI) because this might improve the quality of their own work. For example, from MTs, there were comments such as, "what is the relation between the cytological diagnosis of mammary gland tissue and ultrasound and mammography image interpretation?" and "when a neck ultrasound examination is conducted, it is good sometimes for the patient to be referred for an MRI." From PTs, the comments received included the following: "when a rehabilitation plan of rotator cuff injury is being prepared, it is good if the patient can be referred for a shoulder MRI" and "I want to know the interpretation of a chest X-ray to be able to make a reference to it in the process of arranging rehabilitation for heart failure." There

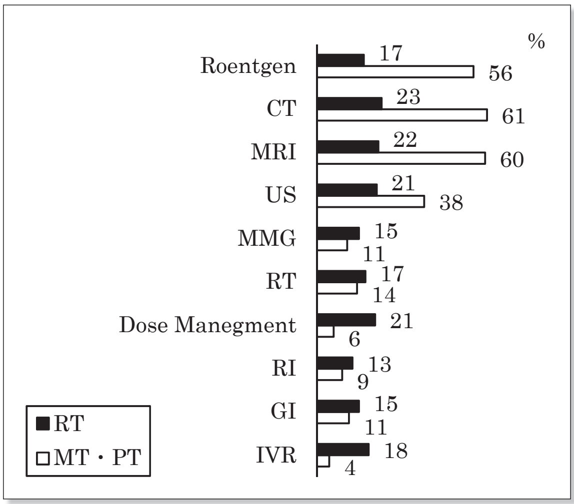

Fig.8 Aspects of RT work demanding interprofessional cooperation

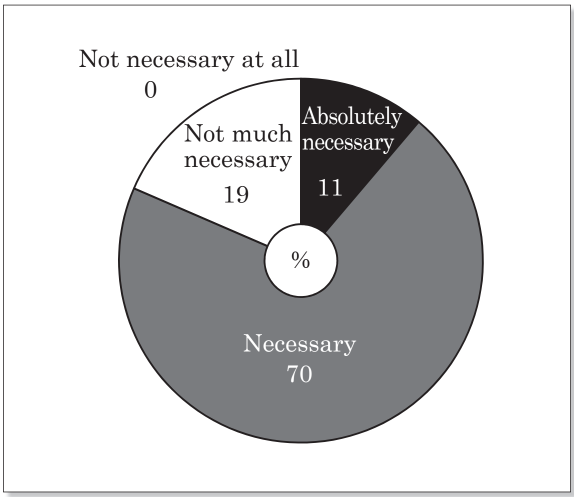

Fig.9 The demand for interprofessional cooperation between RTs, MTs, and PTs

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were a minority of opinions such as demanding to know more information about ultrasound, radiotherapy, and other aspects of a RTs work.

Examples of the demands that RTs make to MTs were, "I would like to refer to the clinical laboratory test results and the electrocardiogram data to assist CT and MRI interpretation" and "I would like to know the interpretation of pathological examinations to compare them with medical images." Most of the RTs comments to PTs were about safe and easy transfer of information corresponding to the different ways in which the patients pass through each department.

5. Discussion

【Profile】

There were 10 non-respondents in Question 3, regarding the experience of the respondents. This included three RTs, five MTs, and two PTs. This might have been because they had forgotten the length of time in their job or had refused to fill the question. The results showed that RTs and MTs had a longer length of experience in their work than PTs and, on average, this was about two-fold greater. RTs and MTs with greater experience possibly find it easier to carry out their own duties and oversee not only their own job but also that of other departments or the facility as a whole. Therefore, their realization for interprofessional cooperation might be different from that of PTs that only have a short length of experience in their work.

【About other professions】

As shown in the result for Question 4, since Drs and Nss cooperate with the three professions, RT, MT, and PT, the recognition of their work was high. However, since the cooperation among RTs, MTs, and PTs is almost unlikely, the recognition of each of their work was low.

Self-recognition of the work of RTs was below 100% (Question 5). Thirteen RTs did not recognize all of the roles and responsibilities of the job. If their result was excluded, the self-recognition of RTs became 97%, which is almost that that would be expected. For the other job categories, there was variation in the recognition of the roles and responsibilities of RTs. Medical imaging, such as radiography, CT, and MRI provide many opportunities to be referred during clinical examination and rehabilitation planning. Conversely, gastrointestinal examination and nuclear medicine examination have fewer opportunities to be referred. For example, when MTs conduct ultrasonic examination, CT and MRI images are often referred to. Furthermore, image fusion is sometimes performed to identify the site of a lesion and to determine the inspection procedures[7]. Even for PTs, the understanding of medical images is indispensable to treat stroke and joint diseases, for example[8-11]. The recognition of ultrasonic examination as a responsibility for RTs was greater than half. Ultrasound is clinically divided into sub-territories as abdomen, heart, neck, blood vessels, etc. MTs are also involved in one specialized area, and PTs use ultrasonic imaging for evaluating muscles. Approximately half of the respondents recognized that mammography and radiotherapy were roles for RTs. It seemed to be an effect of the enlightenment of breast cancer screening and recent catching attention in the media[12-13]. The breakdown of gender in the recognition of mammography was 61% for males and 54% for females, showing no significant gender difference. The recognition of IVR was the lowest. In this questionnaire, only the name of work was presented. Therefore, it is possible that other professionals could not understand what an IVR examination involves. If we had inserted the description of what IVR entails then its recognition may have been higher.

【About interprofessional cooperation】

"Team approach by the medical team" and "Information exchange/contact" occupied the first and second priorities, respectively, in Question 6. Many medical staff seemed to be conscious of direct collaboration in doing work such as IVR and nutrition support. A "joint study group" gave a lower response than the former two priorities. This may be due to the fact that it may be hard to imagine what kinds of themes should be discussed in such a meeting. Also, many staff may feel that there would be no opportunity to hold a meeting because their own job is so busy. As shown in the results for Question 7, there seem to be many opportunities to be involved with Drs and Nss. However, there seem to be fewer opportunities for RTs, MTs, and PTs to be involved with each other. This result was similar to that for Question 4 (Fig.4).

【Potential for interprofessional cooperation in the future】

There were few responses about interprofessional cooperation by RTs in Question 8. It is considered that the final level of cooperation varies between individuals. It may have been necessary to provide appropriate criteria in the questionnaire. The responses of the other professionals suggested that image observation is an area that would benefit from interprofessional cooperation. This result was similar to that of Question 5 (Fig.5).

The breakdown of non-respondents in Question 9 was two RTs, six MTs, and three PTs. They might not have known how necessary interprofessional cooperation is in their job or may have refused to answer, as in Question 3. In the case of the RTs, the transfer of a wheelchair- or bed-bound patient onto the examination table is carried out on their own or supported by Nss. When a CT/MRI examination is conducted, RTs also refer to the results of blood tests such as inflammatory reactions, renal function, etc. Therefore, because there are things in common with other professionals to carry out their work, there are collaboration demands among each of the three professions. However, since there are few contact points in clinical practice presently, there is no opportunity for interprofessional cooperation.

In Question 10, some detailed demands from the three professions emerged. It is important to understand that they want to learn about the roles of other professions and want to try to improve the quality of their own work.

In this survey, we were able to understand the current situation and demands of RTs, MTs, and PTs in the recognition of their roles and responsibilities and the goal of interprofessional collaboration. As a result, there are many parts of each profession that are not known. From this survey, we took some hints from the results regarding collaboration which have led to the improvement of our own work and improvement of medical safety. Because this survey was conducted through CoMSEP graduates, the respondents were limited to only three professions. However, team medicine requires a wide area of cooperation regardless of profession. For example, in the area of RT, there are several reports from medical physicists and pharmacists in radiotherapy [14-16], and clinical engineers in IVR or MRI [17], etc. In emergency or disaster medical care, RTs are required to cooperate in terms of patient care and medical safety, similarly to other medical staff [18-20]. In addition, infection control and equipment management are common to all professions [21-22]. We need to consider hospital-wide problems as well. In the future, in order to develop interprofessional cooperation, we must cooperate across all professions [23-25]. Communication is mentioned as an important element for interprofessional cooperation [26-27]. Each profession is independent because they are busy and have strong technical expertise. Interprofessional cooperation has already begun with small things such as greeting and socializing with each other. Understanding and being interested in the work that everyone performs is important for interprofessional cooperation.

6. Summary

The recognition of the roles and responsibilities of RTs, MTs, and PTs was lower than that of Drs and Nss. It was suggested that the strategy should be to increase awareness of the roles and responsibilities of each job category in each facility. This survey identified the necessity and demand for cooperation among the professions questioned. We were able to obtain useful information to promote interprofessional cooperation.

7. Acknowledgments

We thank the CoMSEP graduates who completed the questionnaire.

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Usefulness of volunteer activities for radiological technologist course students

Koji Nakaya, Hiroe Muto, Kanae Matsuura, Satoshi Nakanishi

Department of Radiological Technology, Faculty of Health Science, Suzuka University of Medical Science: Teacher

Key words: volunteer, communication, radiological technologist

【Abstract】

The department of radiological technology of our university promotes volunteer work for first-year students. We conducted a survey of volunteer awareness to evaluate the usefulness of the volunteer work to students. The students indicated their reason for volunteering and their grasp of the necessary abilities of medical personnel. Some students expressed the thought that communication was difficult as a result of their volunteer experience. In this research, it was possible to analyze the students' understanding of the significance of volunteer work and their grasp of the abilities needed by medical staff. In addition, our results suggest that this volunteer program is beneficial to students.

1. Introduction

In our department, we are promoting volunteer activities for one week at a special nursing home for the elderly located in the local community at the time of first-year. For students aiming to become medical professionals, what they directly experience about medical care through volunteering will become the basis of their work as medical professionals [1] in the future, and will be able to recognize again that they will become medical professionals in the future. It will also encourage their study of specialized subjects in the future. We are promoting volunteering among first-year students who are not knowledgeable about medical care to convey to them the role of medical personnel, help them acquire knowledge of medical personnel, and to cultivate the skills needed by medical personnel. Therefore, we conducted a survey of first-year students on their awareness of the educational effect of volunteering to work as radiological technologists.

2. Material and Methods

2-1. Targets

The target of the consciousness survey was the first-year students (126 people) of our department in FY 2017. We instructed the students to set the number of days for volunteering at 3–5 days. The questionnaire was conducted before and after the volunteer activities (twice total). The questionnaire was answered through the university's portal system, and their personal information was anonymized and discarded.

2-2. Survey items

In the questionnaire survey before the volunteer activity, we investigated their earlier volunteer experience, their purpose in volunteering, and their self-analysis of the abilities necessary for medical personnel. The purpose of volunteering was to investigate three items (①I thought it would be useful to become a radiological technologist, ②I felt its significance as a medical person, ③I wanted to help others), and the choices were "applicable" and "not applicable." Self-analysis of the abilities needed by medical personnel before volunteer activity concerned nine items: ①the ability to progress by themselves, ②the ability to arrange their own ideas, ③the ability to verbally convey ideas to others, ④the ability to understand and listen to the opinions of others, ⑤the strength to respect and listen, ⑥the power to act in the group, ⑦the size of the voice (size conveyed to others), ⑧the ability to act by reading ahead, and ⑨the ability to manage the physical conditions (complete the volunteer work). The possible responses were “Yes” and “No.”

In the questionnaire survey after the volunteer activity, we investigated their revaluation after volunteering of their reasons for volunteering, their self-analysis of the skills needed by medical personnel, and the satisfaction they felt in their volunteer work. The survey items on their re-evaluation of their reasons for volunteering and their self-analysis of the abilities necessary to medical personnel after the volunteer activities were the same as before the volunteer activities, while the degree of satisfaction after the volunteer activity was rated at the four levels of “very good,” “good,” “bad,” and “very bad.”

We also investigated the impression of volunteer activities through volunteers’ free descriptions.

2-3. Statistical analysis

Pearson’s chi-square test was used to determine statistically significant differences in the results of the questionnaire survey before and after the volunteer activity.

3. Results

3-1. Survey collection rate

The questionnaire response rate before the volunteer activity was 80.2% (age: 19 ± 0.68 years old, sex: 58 males, 43 females). The questionnaire response rate after the volunteer activity was 81.0% (age: 19 ± 0.69 years old, sex: 57 males, 45 females). There was no significant difference by age or sex before and after the volunteer activity (n.s.).

3-2. Previous volunteer experience

Fig.1 shows the previous volunteer experiences of the students. The number of students who performed volunteer work in the past was 51% (52 people), and that of students who had not was 49% (49 people).

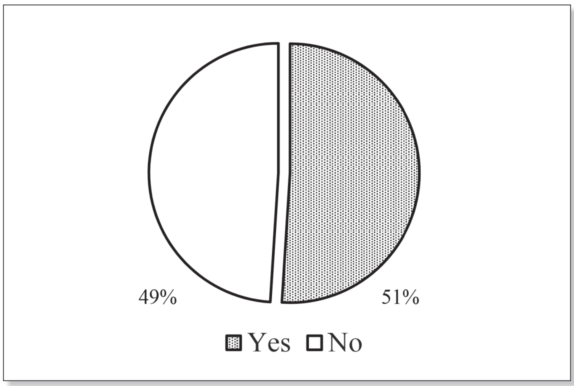

Fig.1 Presence of volunteer experience

3-3. Survey of the students’ reasons for volunteer activities

The results of the questionnaire on their reasons for the volunteer activity are shown in Fig.2. Before volunteering, the answers of “applicable” were ①71% (72 people), ②85% (86 people), and ③90% (91 people), respectively, whereas after the volunteer activities, the an-

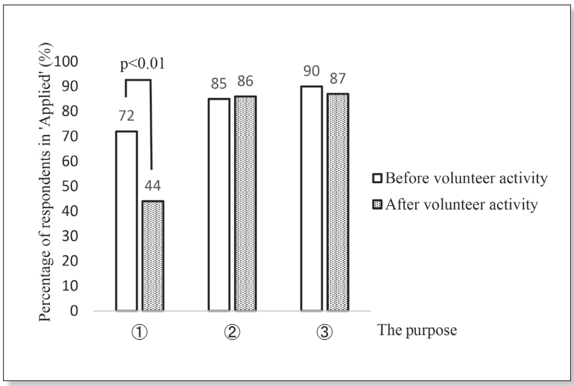

Fig.2 Answer for the purpose of doing volunteer activities

①I thought it would be useful for becoming a radiological technologist, ②I felt the significance as a medical person, and ③I wanted people to help

Regarding the significant difference test of responses before and after the volunteer, Pearson’s chi-square test was conducted. There was significant differences between before and after of volunteer activities in item ①only (p<0.01). There were no significant differences between before and after of volunteer activities in item ② and ③ (n.s.).

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swers of “applicable” were ①44% (45 people), ②86% (88 people), and ③87% (89 people), respectively. In addition, a significant difference was found before and after the volunteer activity ($p < 0.01$) for the answer to ①.

3-4. Self-analysis of the abilities needed by medical personnel

The questionnaire results on the students’ self-analyses of the abilities necessary for medical personnel are shown in Fig.3. Before the volunteer activities, the responses of “Yes” were ①59% (60 people), ②78% (79 people), ③41% (41 people), ④83% (84 people), ⑤89% (90 people), ⑥77% (78 people), ⑦72% (73 people), ⑧61% (62 people), and ⑨88% (89 people), respectively, while after the volunteer activities, the responses of “Yes” were ①69% (70 people), ②86% (88 people), ③61% (62 people), ④93% (95 people), ⑤99% (101 people), ⑥84% (86 people), ⑦80% (82 people), ⑧67% (68 people), and ⑨95% (97 people), respectively. We note that in the responses to ③, ④, and ⑤ significant differences were found before and after the volunteer activities ($p < 0.05$).

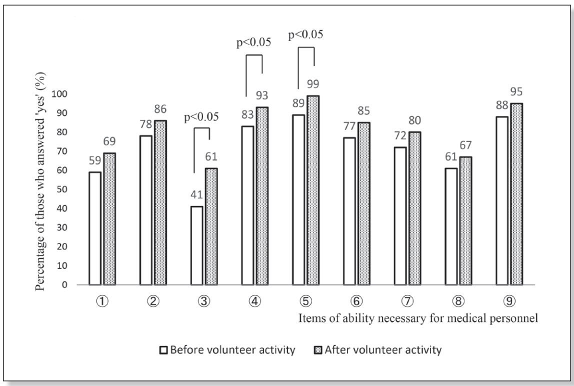

Fig.3 Self analysis of ability necessary for medical personnel

①Ability to work on its own, ②Ability to organize my thoughts, ③Ability to communicate your thoughts orally to other people clearly, ④Ability to understand and listen to the opinions of others, ⑤The ability to respect others’ opinions and listen, ⑥Ability to act in the group, ⑦Size of voice (size conveyed to others), ⑧Ability to act in advance, and ⑨ I can manage physical condition (I will be able to volunteer until the end)

Regarding the significant difference test of responses before and after the volunteer, Pearson’s chi-square test was conducted. There were significant differences between before and after of volunteer activities in item ③, ④, and ⑤ (p<0.01). There were no significant differences between before and after of volunteer activities in item ①, ②, ⑥, ⑦, ⑧ and ⑨ (n.s.).

3-5. Volunteer satisfaction

The results of the questionnaire on their degree of satisfaction with the volunteer activities are shown in Fig.4. The numbers of answers of “very good,” “good,” “bad,” and “very bad” were 22% (23 people), 72% (73 people), 4% (4 people), and 2% (2 people), respectively.

3-6. Free description

The students provided numerous positive comments on doing volunteer work: “I understood the importance of communication,” “I had a good experience over a short period,” “I’d love to volunteer even as a second-year student,” “I was able to experience what it is like to be a medical person,” “I found out how to contact people,” “It was a good life experience,“ and “I realized that I do not have my own power, and I was able to look back on how to contact people.” On the other hand, one negative comment indicated that “I do not know how this experience will be useful to become a radiological technologist.”

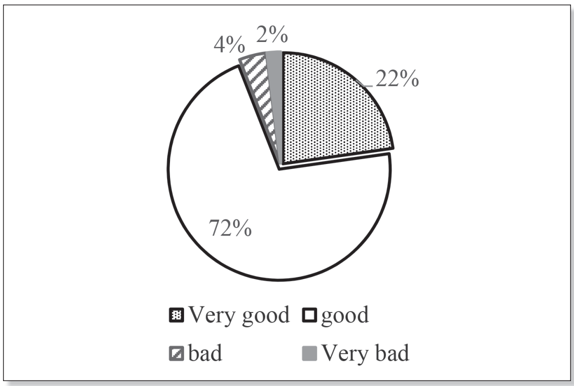

Fig.4 Evaluation of volunteer satisfaction

Volunteer’s satisfaction rating was done in four stages of “very good”, “good”, “bad”, and “very bad”.

4. Discussion

In this research, we promoted volunteer activities for first-year students aiming to become radiological technologist, and investigated whether they understood the meaning of volunteering and were able to grasp the necessary abilities of medical professionals. About half of the students had volunteered in the past. There are elementary, middle, and high schools whose students volunteer as a part of class [2], and it would appear that an increasing number of schools encourage voluntary social contributions.

Turning to the reasons for volunteering, there were no significant differences in the answers before and after the volunteer work for the items "I felt the significance of being a medical person" and "I wanted to be useful" (n.s.), to which approximately 90% of the students answered "applicable." That is, 90% of the students worked on volunteer activities in a spirit of medical professionalism and service and reaffirmed the significance of volunteering. However, there was a significant difference before and after volunteering on the item "I thought it would be useful for becoming a medical radiological technologist" (n.s.). The number of students who replied "applicable" decreased after volunteering. Although volunteers were able to cultivate their communication skills, there was at least one student who did not recognize that communication abilities are one of the necessary abilities of radiological technologist, as shown by the statement that "I do not know how this experience will be useful for becoming a medical radiological technologist" on the free description. Since first-years do not fully understand the work of radiological technologist, there are students who believe that communication skills are unnecessary. In addition, some students think that radiological technologists only carry out X-ray photographic work. In clinical practice, communication establishes a relationship of trust with doctors or other professionals, which is important in our duties of providing high-quality medical care to patients [3]. In addition, communication with staff helps prevent medical accidents through human error and other factors [4]. Therefore, it is desirable to establish relationships of trust between the staff in various fields [5-6]. Communication is regarded as a very important factor in medical welfare [7]. As indicated above, the radiological technologist is a member of the medical care team, and communication is thus an essential ability for the radiological technologist. If students volunteer while feeling that communication is not a necessary ability of the radiological technologist, their motivation will definitely drop and they will fail to understand the meaning of volunteering. Therefore, in order to maximize the significance of volunteering, it is necessary to have students participate in volunteering only after understanding that communication is necessary to the work of radiological technologists. This is our future task.

The self-analysis of the abilities necessary for medical staff did not show a significant difference before and after volunteering on six items: "The ability to act by oneself," "the ability to arrange one's own ideas," "power to act in the group," "size of the voice (size conveyed to others)," "ability to act by reading ahead," and "able to manage the physical conditions (complete the volunteer work)." It can be said that students themselves understand the importance of such abilities as initiative power, group behavior, and physical condition management.

However, there were significant differences on the items of communication ability: "the ability to verbally convey ideas to others," "the ability to understand and listen to the opinions of others," and "strength to respect and listen" before and after volunteering ($p < 0.05$). On these items, the number of respondents who answered "Yes" after the volunteer work increased. We think that this indicates an increase in the number of students who recognized and were able to self-analyze their own communication skills through volunteering. However, while the number of students who answered "Yes" to the item "the ability to verbally convey the idea of others to others" increased after volunteering, the number of "Yes" answers for this item was the lowest of all the items. Many students think that it is difficult to communicate their thoughts to others, which is consistent with the fact that more students feel that communication is difficult in modern times [8]. To produce high-quality radiological technologists, we need to educate students not only in the specialization of the radiological technologist, but also improve students' communication skills.

In the survey on satisfaction of volunteer activities, 94% of the students felt that it was good to conduct volunteer activities. As they described in the free description, volunteers were able to feel the importance of communication, which led to reinforcing their intention to become a medical professional by being able to experience the work of a medical person. The level of their satisfaction with volunteer activities was high because this volunteer experience helped them to strengthen their intention to become a medical professional and to develop their requisite abilities. However, 6% of students said that their satisfaction level as volunteers was bad. Some students offered the negative comment that they did not understand communication as a necessary skill of the medical radiological technologist. We must decrease the number of such students in the future. Before participating in volunteer activities, all students must understand the importance of communication skills.

From the above, it appears that students' volunteer activities are useful in their education. However, some students felt that volunteering was useless in becoming a radiological technologist. Since radiological technologists are often engaged in business in cooperation with other occupations, students need to develop a modicum of communication skills through volunteering. We need to make these students understand that communication is an important ability of the radiological technologist. Furthermore, all students must understand the necessity of communication and apply these skills in their volunteer work. Volunteer work will constitute a foundation for becoming a health care professional in the future and will be able to strengthen the student's intention of becoming a radiological technologist in the future. Because doing so will also help to improve the study of special subjects in the future, we urge the continued promotion of volunteer activities to produce better radiological technologists.

This study covered first-year students. In the future, we would like to investigate the difference in the educational effect of volunteering on students in different years.

5. Conclusion

In the questionnaire survey before and after the volunteer activities, we were able to analyze the perceived usefulness of volunteer work to the students and the degree to which they grasped the abilities needed by medical personnel. Promoting volunteer work is useful in training students aiming to become radiological technologists, but there were students who did not understand that the communication skills that can be cultivated by volunteer work are a necessary ability of radiological technologists. This study found that improving communication skills is an indispensable part of the education of radiological technologists.

This research was presented at the 33th Japan Conference of Radiological Technologists (Hakodate).

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Comparison of measured values on ^{11}C-methionine and ^{18}F-fluorodeoxyglucose PET obtained with two different scanners in normal brain and brain tumor

Yu-ichi Yamada[1), 2)], **Yoshitaka Asano**[2), 3)], **Seisuke Fukuyama**[1)], **Ryo Tanokura**[1), 2)], **Yuka Ikegame**[2), 3)], **and Jun Shinoda**[2), 3)]

1) Chubu Medical Center for Prolonged Traumatic Brain Dysfunction, Kizawa Memorial Hospital, Department of Radiotechnology
2) Department of Clinical Brain Sciences, Gifu University Graduate School of Medicine
3) Chubu Medical Center for Prolonged Traumatic Brain Dysfunction, Kizawa Memorial Hospital, Department of Neurosurgery

Key words: PET, acquisition system, SUV, T/N ratio, brain tumor

【Abstract】
OBJECTIVE. The purpose of this study is to investigate if there were differences between the measured values obtained with 2-dimensional (2D-system) versus 3-dimensional acquisition system (3D-system) in positron emission tomography (PET) scans of the normal brain and brain tumors. **MATERIALS AND METHODS.** PET scanning with ^{11}C-methionine (MET-PET) or ^{18}F-fluorodeoxyglucose (FDG-PET) was performed using two scanners which were equipped with 2D-system and 3D-system. In 121 patients with various types of brain tumors, Regions of interest were placed in the normal brain structures and the standard uptake values (SUVs) were measured. In 35 patients with diffuse astrocytoma and 18 patients with meningioma, the tumor/normal brain ratio (T/N ratio) was calculated using the maximum SUV of the tumors and the mean SUV of the normal frontal cortex. **RESULTS.** The mean SUV of the normal brain structure acquired on the 3D-system was significantly lower than those on 2D-system for both MET and FDG-PET. The mean T/N ratio of diffuse astrocytoma from 3D-system was significantly lower than that from 2D-system with MET-PET, but there was no significant difference in the T/N ratio with FDG-PET in both brain tumors. **CONCLUSION.** This study suggest that with tumors in which the SUV was higher than that of the normal brain, which resulted in a lower T/N ratio obtained with 3D-system than that with 2D-system. With tumors in which the SUV was equal to or lower than that of the normal brain, which resulted in a T/N ratio obtained with 3D-system was approximately equal to that with 2D-system.

PURPOSE

Diagnosis of brain tumor by molecular imaging is essential for the evaluation of malignancy, prognosis, and to suggest a strategy for treatment [1-11]. Also, for brain tumors, a number of studies that report the use PET scanning have been published. In this decade, our group has published several studies of brain tumors and related diseases in which PET was used as the critical diagnostic modality [12-15]. Recently, the number of clinics that use PET scanners has increased. At the present time, there are five medical equipment production companies producing PET scanners in the world. We need more comparative discussions regarding PET imaging of brain tumors obtained from different types of scanners worldwide in the literature and at meetings. In such settings, the data obtained from the different PET scanners used in the various institutes may not correspond. This issue should be noted and the measured values should be investigated. In our hospital, we had been using an ADVANCE NXi (NXi) Imaging System, equipped with a 2D acquisition system, and then transitioned to an Eminence STARGATE (SG), which is equipped with a 3D acquisition system. There was a large amount of accumulated data in brain tumors, which could be compared and differences in the data characteristics obtained from the two different PET scanners could be evaluated. To the best of our knowledge, there are no previous investigations comparing brain tumor imaging from a 2D acquisition system to that from a 3D acquisition system. The purpose of this study is to investigate if there were differences between the measured values obtained with 2D versus 3D acquisition systems from PET scanners in the normal brain and brain tumors.

MATERIALS AND METHODS

PET scanner

Data used in this study were obtained from two different PET scanners. One was an ADVANCE NXi Imaging System equipped with a 2D acquisition system that provided 35 transaxial images at 4.25 mm intervals with an in-place spatial resolution (full width on transaxial images) of 4.8 mm and an aperture width of the Z-axis direction of 150 mm (General Electric Yokogawa Medical Systems, Hino, Tokyo, Japan) (NXi), which had been used from 2006 to 2011. The other scanner was an Eminence STARGATE equipped with a 3D acquisition system that provided 99 transaxial images at 2.65 mm intervals with an in-place spatial resolution (full width on transaxial images) of 3.5 mm and an effective visual field of the Z-axis direction of 260 mm (Shimadzu Corporation, Kyoto, Japan) (SG), which has been used since 2011. The PET radiotracers, ^{11}C-methionine (MET) and ^{18}F-fluorodeoxyglucose (FDG) were used in this study. Table 1 indicates the mechanical characteristics of these two scanners.

Table 1 Summary of the characteristics of the two PET scanners

	NXi	SG
Equipped detector	BGO	GSO
Detector size (mm)	4.25×35	3.25×99
Aperture width (mm)	150	260
Acquisition system	2D	3D
Special resolution (mm)	4.2	3.5
Reconstruction	OS-EM	DRAMA
Iteration	2	1
Subset/Filter Cycle	14	128
Matrix	128×128	128×128

Patients

4,602 patients with brain tumors received PET scans in the Chubu Medical Center for Prolonged Traumatic Brain Dysfunction, Kizawa Memorial Hospital from July 2006 to March 2013. Among them, 121 randomly selected patients with various types of localized small brain tumors were enrolled in this study for the evaluation of the measured values on PET in normal brain structures. For the PET scanning, the NXi was used in 66 patients (mean age: 42.3 ± 13.6 years, 33 males) and the SG was used in 55 patients (mean age: 44.2 ± 14.5 years, 33 males). In addition, another 35 patients with diffuse astrocytoma (DA) and 19 patients with meningioma (MEN) that had the tumor type histologically confirmed were also enrolled in this study. For the PET scanning in patients with DA, the NXi was used in 20 patients (mean age: 47.4 ± 16.3 years, 10 males) and the SG in 15 patients (mean age: 44.5 ± 19.9 years, 8 males). For PET scanning in patients with MEN, the NXi was used in 13 patients (mean age: 68.0 ± 10.6 years, 4 males) and the SG in 6 patients (mean age: 63.5 ± 24.2 years, 1 male). Patients with DA or MEN were included in this study because these tumor types were representative tumors in which the radiotracer uptake within the lesions is homogeneous from our experience. No patients had undergone prior surgeries or adjuvant therapies. The study was approved by the institutional review board (27-025), and all subjects signed a written informed consent [or need for written informed consent was waived].

Data acquisition on PET

Participants were placed in the PET scanner so that axial slices were parallel to the canthomeatal line, and the head was fixed to reduce body movement during the scan. In the NXi, a germanium-68 gallium rotating pin source was used to obtain a 3-min transmission scan and the radiopharmaceutical (MET: 5.0 MBq/kg, FDG: 5.0 MBq/kg) was injected intravenously via the cubital vein. With the MET-PET, we started a 30-minute emission scan 5 minutes after administration of the radiopharmaceutical and with the FDG-PET, a 7-minute emission scan was acquired at approximately 35 minutes after administration. Conversely, with the SG, a cesium-137 rotating pin source was used to obtain a 4-min transmission scan and the radiopharmaceutical (MET: 3.5 MBq/kg, FDG: 3.5 MBq/kg) was injected intravenously via the cubital vein. With the MET-PET, we started a 35-minute emission scan at the time of administration, and with the FDG-PET, a 10-minute emission scan was acquired approximately 45 minutes after radiotracer administration.

The static scans were reconstructed with attenuation correction using data from the transmission scan. The PET images were co-registered to an MRI that was performed on the same day, for better anatomical determination. Image fusion was performed by an image analysis program in combination with Dr. View/Linux image analysis software (Asahi Kasei Information System, Tokyo, Japan), using a method described by Kapouleas, et al. [16].

In the 121 patients with various brain tumors, 10 mm circular regions of interest (ROIs) were drawn manually with reference to the MRI which was superimposed on the PET image in normal brain structures that included the brainstem, thalamus, grey and white matter, and cerebellum, and avoided regions which were shifted or invaded by brain tumors or edema. ROIs were decided with agreement of three neurosurgeons and three radiological technologists who are experts in PET examination. As a rule, the ROIs in the grey and white matter were placed bilaterally in the frontal side of the parietal lobe in which the body of the lateral ventricles couldn't be seen (Fig.1), however if the frontal side of the parietal lobe was shifted or invaded by brain tumor or edema, the ROIs were placed toward the occipital side of the parietal lobe. The ROIs in the thalamus were placed at the center of the thalamus bilaterally in the plane in which the basal ganglia could be seen (Fig.1). Eight of the ROIs in the thalamus in NXi and eleven of those in the thalamus in SG were omitted because those were shifted or invaded by brain tumors or edema. The ROIs in the cerebellum were placed bilaterally in the plane in which the cerebellopontine angle could be seen (Fig.1), and the ROIs in the brainstem were placed in the middle pons level, as reported by Uda et al. [17] (Fig.1). A summary of all the ROIs are detailed in Table 2.

The ROIs in the DAs were manually drawn by tracing the tumor boundaries in an axial plane of a fusion image of the T2WI/MET-PET and the T2WI/FDG-PET (Fig.2) and those in the MENs were also manually drawn by tracing the boundaries in an axial plane of a fusion image of the contrast-enhanced T1WI/MET-PET and the contrast-enhanced T1WI/FDG-PET (Fig.2).

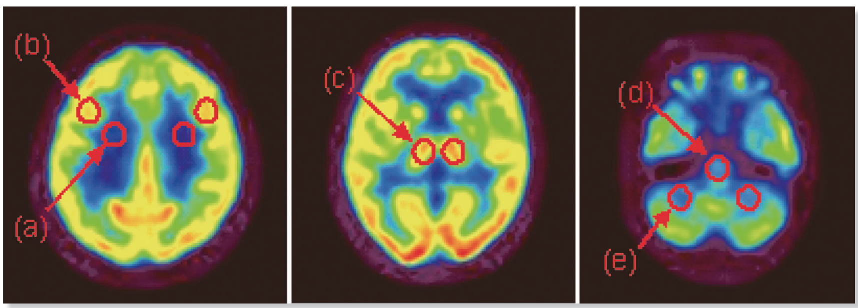

Fig.1

The ROIs placed in the normal grey matter (a), white matter (b), thalamus (c), cerebellum (d), and brain stem (e) on FDG-PET.

Table 2 Summary of all the ROIs in the normal brain structures

	The number of ROIs	
	NXi (n=66)	SG (n=55)
Evaluation of normal brain structures		
grey matter	132	110
white matter	132	110
thalamus	124	99
cerebellum	132	110
brainstem	66	55

The ROIs in the normal control cortex were manually drawn by tracing the contra-lateral frontal cortex in an axial plane of a fusion image of the T2WI/MET-PET and the T2WI/FDG-PET in which the basal ganglia could be seen (Fig.2), and in the superior and inferior axial planes of a fusion image of the T2WI/MET-PET and the T2WI/FDG-PET in which the basal ganglia could be seen. We calculated the mean SUV of the contra-lateral normal frontal cortex from three ROIs.

The regional MET and FDG uptake in the ROIs was expressed as a standard uptake value (SUV) calculated by the following formula;

SUV = (tissue activity/ml)/(injected radiotracer activity/body weight (g))

In the MET and FDG-PET, the maximum SUV tumor/normal control cortex uptake ratios (T/N ratios) of the DAs and MENs were calculated by the following formula;

T/N ratio = the maximum SUV of the tumor / the average of the mean SUV of the contralateral normal frontal cortex

Statistical Analysis

The mean SUVs of the normal brain structures, the maximum SUVs of the DAs and the MENs, the mean SUVs of the normal control cortex, and the mean T/N ratio of the DAs and the MENs obtained from the NXi versus those from the SG were compared statistically using an independent t-test in the MET and FDG-PET, respectively. Differences with a threshold of $p<0.05$ were considered statistically significant. All data were analyzed using SPSS 2 for Windows.

RESULTS

MET-PET

The mean (± SD) of the mean SUVs in the normal grey matter were 1.34 ± 0.29 versus 1.69 ± 0.45 for the NXi versus the SG, respec-

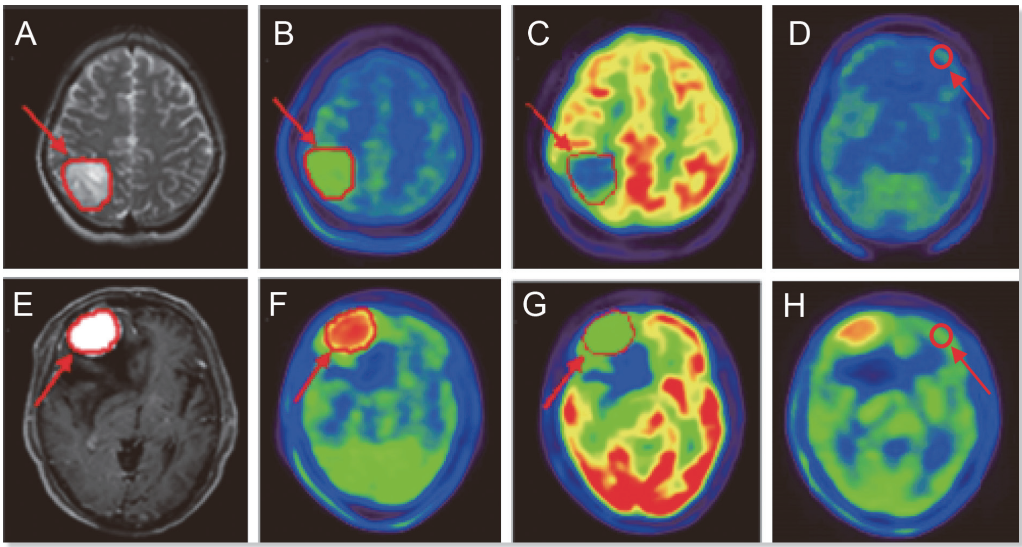

Fig.2

The ROIs placed on the T2WI (A), the MET-PET (B), and the FDG-PET (C) in a case of DA. The ROIs placed on the contrast-enhanced T1WI (E), the MET-PET (F), and the FDG-PET (G) in a case of MEN. The ROIs in the normal control cortex placed on MET-PET (D, H).

tively. In the normal white matter the SUVs were 0.84 ± 0.20 versus 1.21 ± 0.33, the normal thalamus, 1.47 ± 0.27 versus 2.00 ± 0.52, the normal cerebellum, 1.59 ± 0.32 versus 1.90 ± 0.49, and in the normal brainstem, the SUVs were 1.49 ± 0.33 versus 2.13 ± 0.56 for the 121 patients with brain tumors. The mean of the mean SUV in every normal brain structure obtained with the NXi was significantly lower than that with the SG (p<0.001) (Fig.3).

In the 35 patients with DA, the mean (± SD) of the maximum SUV of the DAs obtained with the NXi (2.34 ± 0.74) was lower than that from the SG (2.74 ± 0.67), however this result did not reach statistical significance (p=0.112) (Fig.4). The mean (± SD) of the mean SUV of the normal control cortex obtained with the NXi (1.13 ± 0.27) was significantly lower than that from the SG (1.70 ± 0.32) (p<0.001) (Fig.4). The mean T/N ratio (± SD) of the DAs obtained with the NXi (2.09 ± 0.45) was significantly higher than the T/N ratio with the SG (1.61 ± 0.23) (p<0.001) (Fig.4).

In the 19 patients with MEN, the mean (±

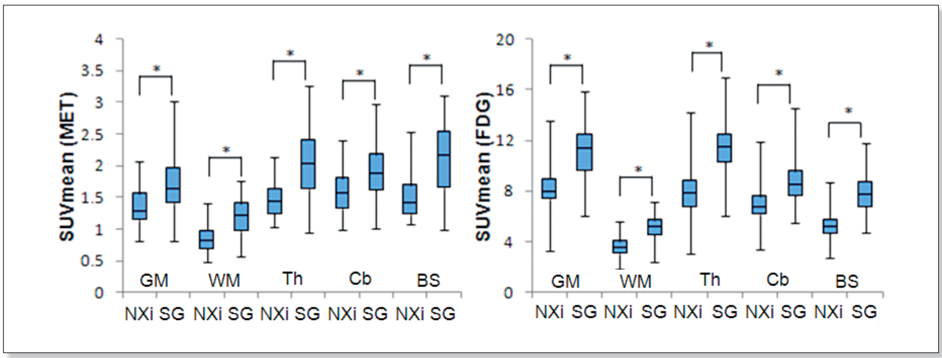

Fig.3

The mean SUVs of the normal grey matter (GM), white matter (WM), thalamus (Th), cerebellum (Cb) and brain stem (BS). Left: MET-PET. Right: FDG-PET. Box-and-whisker plots indicate the distribution (mean and SD). *p <0.001.

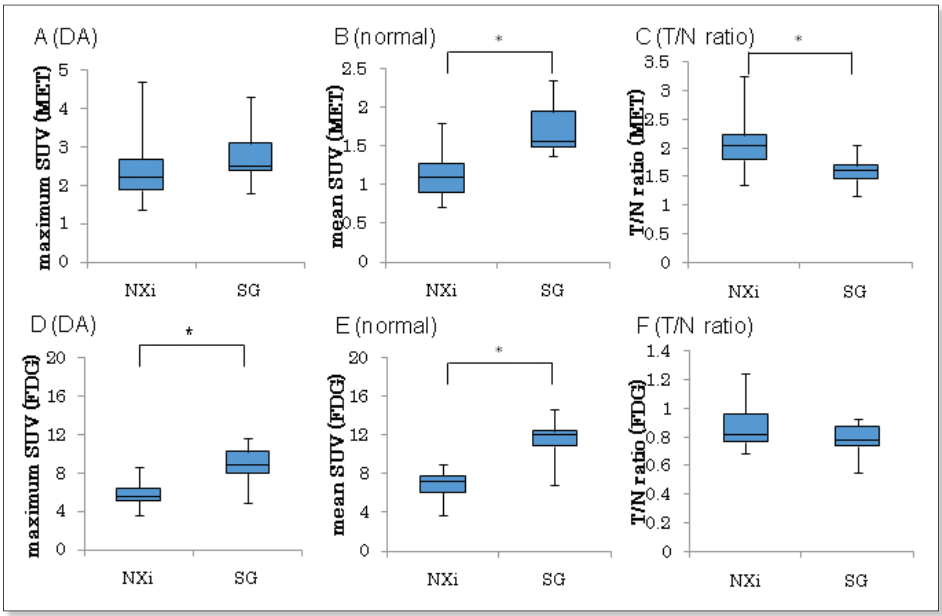

Fig.4

The maximum SUVs of the DAs (A), the mean SUVs of the normal control cortex (B) and the mean T/N ratios of DA (C) on the MET-PET. The maximum SUVs of the DAs (D), the mean SUVs of the normal control cortex (E), and the mean T/N ratios of the DAs (F) with FDG-PET. *p <0.001.

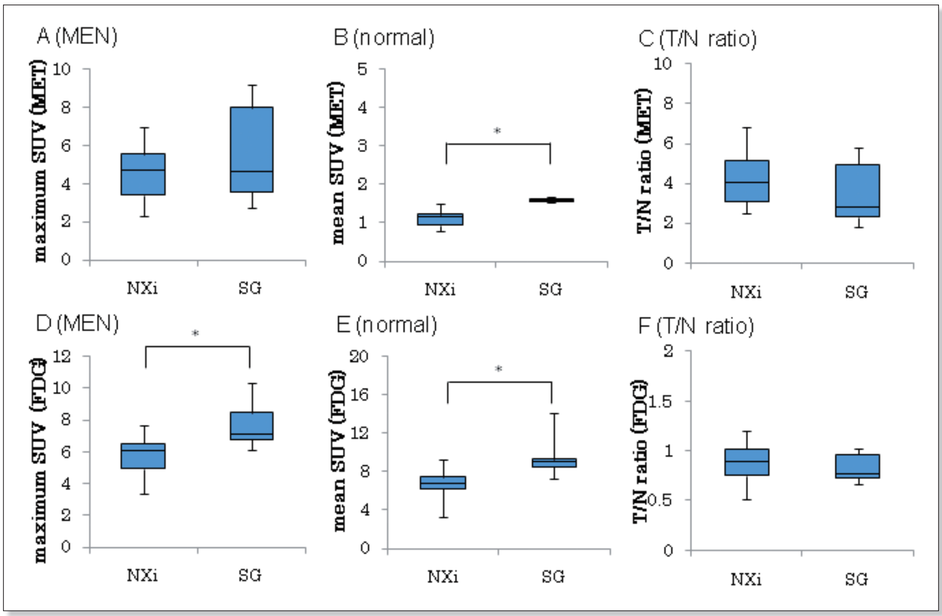

Fig.5

The maximum SUVs of the MENs (A), the mean SUVs of the normal control cortex (B) and the mean T/N ratios of the MENs (C) with MET-PET. The maximum SUVs of the MENs (D), the mean SUVs of the normal control cortex (E) and the mean T/N ratios of the MENs (F) with FDG-PET. *p <0.001.

SD) of the maximum SUV of the MENs obtained with the NXi (4.63 ± 1.46) was lower than the mean SUV with the SG (5.58 ± 2.80), however this result did not reach statistical significance (p=0.333) (Fig.5). The mean (± SD) of the mean SUV in the normal control cortex obtained with the NXi (1.12 ± 0.21) was significantly lower than that with the SG (1.59 ± 0.06) (p<0.001) (Fig.5). The mean T/N ratio (± SD) of the MENs obtained with the NXi (4.21 ± 1.36) was higher than the T/N ratio with the SG (3.50 ± 1.75), however this result also did not reach statistical significance (p=0.333) (Fig.5).

FDG

The mean (± SD) of the mean SUVs of the normal grey matter were 8.08 ± 1.73 versus 11.17 ± 2.05 for the NXi versus the SG, respectively. In the normal white matter, the SUVs were 3.56 ± 0.73 versus 5.08 ± 0.97, the normal thalamus, 7.91 ± 1.85 versus 11.36 ± 2.24, the normal cerebellum, 6.88 ± 1.39 versus 8.71 ± 1.62, and in the normal brainstem, the SUVs were 5.19 ± 1.04 versus 7.71 ± 1.87 for the 119 patients with brain tumors. The mean SUV in every normal brain structure obtained with the NXi was significantly lower than that with the SG (p<0.001) (Fig.3).

In the 35 patients with DA, the mean (± SD) of the maximum SUV of the DAs obtained with the NXi (5.78 ± 1.22) was significantly lower than that with the SG (8.98 ± 1.83) (p<0.001) (Fig.4). The mean (± SD) of the mean SUV of the normal control cortex obtained with the NXi (6.79 ± 1.46) was significantly lower than that with the SG (11.25 ± 1.25) (p<0.001) (Fig.4). The mean T/N ration (± SD) of the DAs obtained with the NXi (0.87 ± 0.15) was increased compared to the DAs with the SG (0.78 ± 0.10), however this result also did not reach statistical significance (p=0.080) (Fig.4).

In the 19 patients with MEN, the mean (± SD) of the maximum SUV of the MENs obtained with the NXi (5.65 ± 1.32) was significantly lower than the SUVs with the SG (7.72 ± 1.58) (p=0.004) (Fig.5). The mean (± SD) of the mean SUV of the normal control cortex obtained with the NXi (6.66 ± 1.40) was significantly lower than that with the SG (9.51 ± 2.39) (p=0.004) (Fig.5). The mean T/N ratio (± SD) of MENs obtained with the NXi (0.87 ± 0.21) was higher than the T/N ratio with the SG (0.83 ± 0.15), however this result also did not reach statistical significance (p=0.673) (Fig.5).

DISCUSSION

In this study, in both the MET and FDG-PET, the mean SUV of every normal brain structure obtained with the NXi was significantly lower than those acquired with the SG. Furthermore, in patients with DA and MEN, the mean SUV of the normal control cortex with the NXi was significantly lower than that with the SG in both the MET and FDG-PET. In agreement with these results, some related studies were found in the literature. Kato, et al. reported that the mean SUV of the normal cortex with MET-PET was 1.25 ± 0.39 or 1.22 ± 0.37, and with FDG-PET was 6.48 ± 1.51 in studies using a PET scanner with a 2D acquisition system [14, 15]. In addition, Miyake, et al. reported that the mean SUV of the normal cortex with MET-PET was 1.52 ± 0.36 and that with FDG-PET was 8.90 ± 8.72 in their study, which used a PET scanner with a 3D acquisition system [4]. The results of these studies support our finding that the mean SUV of normal brain structures with a 2D acquisition system is lower than those obtained with a 3D acquisition system. However, the limitation of these studies is that they were performed in different patients. This finding of lower mean SUVs in normal brain structures with 2D acquisition is likely due to differences in the amount of true, scatter and random coincident radiation between 2D and 3D acquisition systems [18-20]. With a 2D acquisition system, the septa, which are situated in front of the detectors of a PET scanner, can reduce not only true scatter and random coincident radiation in the gantry, but also scattered radiation outside of the gantry.

A 3D system can detect more true coincident radiation than a 2D system, however, at the same time, a 3D system picks up more scattered and random coincident radiation that increase the image noise as compared to a 2D system. Although some devices use various image reconstruction techniques to overcome these noise issues and to improve image quality with 3D systems, the noise reduction is still sub-optimal.

In this study, the maximum SUVs in the DAs and MENs were consistently higher than the mean SUV of the contralateral normal frontal cortex in the MET-PET, however, with FDG-PET, the maximum SUVs in the DAs and MENs were consistently lower than those of the contralateral normal frontal cortex. The maximum SUVs of the DAs and MENs in FDG-PET obtained with the NXi were both significantly lower than those with the SG, although there were no significant differences between those with the NXi and SG using MET-PET. These results suggest that in cases where the SUV is the same as that of normal brain structures or less, the SUV obtained with the NXi is lower than that with the SG regardless of both tumor type and PET tracer used. However, in cases where the SUV is greater than the SUV of normal brain structures, there is no significant difference between the SUVs with the NXi versus the SG.

In the study using a 2D acquisition system by Kato, et al., the T/N ratio of DA with MET-PET was 2.24 ± 0.90 and that with FDG-PET was 0.79 ± 0.08 [14]. In the study using a 3D acquisition system by Singhal, et al., the T/N ratio of DA with MET-PET was 1.56 ± 0.74, and that with FDG-PET was 0.63 ± 0.37 [21]. Using MET-PET of MEN, Aki, et al. reported that the T/N ratio of 5.50-6.62 was obtained using a 2D acquisition system, and in a study using a 3D acquisition system by Arita, et al., the T/N ratio was 2.45 ± 0.67 [12, 22].

With regard to the SUV of the normal frontal cortex used as the denominator of the formula to calculate the T/N ratio, the SUV obtained with the 3D acquisition system was significantly higher than that with the 2D acquisition system in both the MET and FDG-PET. On the other hand, for the SUV of tumors as the numerator of the same formula, there was no significant difference between the SUVs from the MET-PET obtained with the 2D and 3D acquisition systems, because those are markedly higher than normal brain structures in MET-PET. However, because the SUVs of tumors in FDG-PET are lower than those of the normal brain structures, the SUV obtained with a 3D acquisition system is significantly higher than that with a 2D acquisition system as well as the SUV of normal brain structures. This finding explains why the T/N ratio obtained with a 3D acquisition system is significantly lower than that obtained with 2D acquisition system in MET-PET, however, with FDG-PET, there is no significant difference in the T/N ratio obtained with either a 2D or a 3D acquisition system.

We should note that in tumors in which the SUV is higher than that of normal brain structures in PET, the T/N ratio obtained with a 3D acquisition system is lower than that with a 2D acquisition system. However, in tumors in which the SUV is equal to or lower than that of normal brain structures, the T/N ratio obtained with a 3D acquisition system is approximately equal to that obtained with a 2D acquisition system when the measured values obtained with different PET scanners are comparatively evaluated. The results of this study may contribute to the diagnostic comparison of the results of PET examination in brain tumors not only among institutes having different PET scanners but also between data obtain from two types (2D or 3D) of PET scanners even in a single institute.

There a two limitations in this study. First, we should have enrolled identical patients for both PET studies using the 2D and 3D acquisition systems to perform the comparative study exactly. However, because the time period when the 2D acquisition system was used in our hospital was different from the time when the 3D acquisition system was used, studies using both scanners at the same time on the same patients could not be undertaken. Second, DA and MEN were adopted as representative brain tumors in this study because these tumor types are known to have homogeneous radiotracer uptake had within the lesion. It is still uncertain whether the relationship between the tumor SUV and the difference in acquisition type (2D versus 3D) shown in this study will be true in cases of tumors with heterogeneous radiotracer uptake like glioblastoma [23, 24] or in tumors in which FDG has high uptake within the lesions like malignant lymphoma [9]. Further investigations are warranted.

CONCLUSION

The results of this study suggest that in tumors in which the SUV was higher than that of normal brain structures in PET, the tumor SUVs obtained with a 3D acquisition system might be the same as that with a 2D resulting in a T/N ratio with 3D that might be lower than that with 2D. However, in tumors in which the SUV was the equal to or lower than that of normal brain structures, the tumor SUVs obtained with 3D might be higher than those with 2D resulting in a T/N ratio obtained with 3D that was approximately equal to that with the 2D acquisition system.

DISCLOSURE

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