Current Topics on Quality Assurance of X-ray Diagnosis in Japan

Tuguhisa Katoh[a], Keiko Imamura[b], Toru Matumoto[c]

[a]School. of Radiologic Science, Tokyo Metropolitan University of Health Sciences, Tokyo, 16-8551, Japan.
[b]Dept. of Radiology, School of Medicine, St. Marianna University, Kawasaki, 216-8551, Japan.
[c] Research Center for Charged Particle Therapy, Dept. of Medical Physics, Imaging Physics Section, National Institute of Radiology, Chiba, 263-0024, Japan
e-mail: kt29drad@metro-hs.ac.jp

ABSTRACT

Recent topics on quality assurance (QA) of X-ray diagnosis in Japan were reported in this presentation. These were related to mass screening mammography (MMG), lung screening CT (LSCT), skin injury caused by interventional radiology (IVR) and traceable system of dosimeters for x-ray diagnosis. In these successful stories, the author would like to stress the cooperation of all the medical and clinical staff including medical doctors, radiological technologists, medical physicists, manufacturers of medical devices and others.

Keywords: quality assurance, mass screening, mammography, lung screening CT, interventional radiology, traceab le system of dosimeters.

1. INTRODUCTION

In these few years, some topics that would bring a large population dose increment and radiation hazards have been and going to be issued. One was introduction of MMG and helical scanning CT to the mass screening. It was, of cause, carefully evaluated that they would increase the total net benefit to the population. Nevertheless, we must still make efforts to optimize the usage of radiation including QA of the diagnosis. The other was the radiation skin injury caused by IVR, which has been rapidly popularized in Japan. The skin injury might be minor than the severe heart attack or cerebral apoplexy leading to the death. We, however, must try to avoid the hazard or reduce the severity.

Medical physicists in Japan have been and will be filling an important role in these problems. Some activities were reported in this presentation.

2. QA OF MAMMOGRAPHY IN BREAST CANCER MASS SCREENING

2.1. Outline of QA System

A nation wide QA system was required for the optimization of mass screening. Before the mammographic mass screening was started, the QA system was designed in cooperation with radiologists, surgeons, gynecologists, radiological technologists and medical physicists[1-2]. The working group published a quality control (QC) protocol[3] based on the QC manual published by American College of Radiology[4]. The working group held QA seminars to popularize the protocol. A nation wide survey[5-8] was performed to know the technical status. Consultations and concrete recommendations were given to the institutions that could not satisfy the minimum requirement of the protcol, and the technical level had been much improved. Since 2000, MMG has been thus supported by the Ministry of Health Labor and Welfare to be the standard method for mass screening of breast cancer in Japan. The activities of the working group have been inherited by the Central Committee on Quality Control of Mammographic Screening.

2.2. Nation Wide Survey

The nation wide survey was performed in 1997 and 1998 for 104 institutions whose staff had attended to the QA seminar. A RMI 156 phantom, radiophotoluminescent dosimeter (RPLD) badges and a questionnaire were send to each institution. The questionnaire included the questions on instrumentation and materials, technical factors and film processing conditions. The visibility of lesion model images in the returned film was scored according to the protocol

by subjective observation. The background density, contrast of 4 mm thick resin plate and speck image were quantitatively evaluated. The average glandular dose and the HVL of the beam were evaluated from the RPLD badge.

As the results, images of 76 % institutes satisfied the requirement of the protocol. The average glandular dose ranged from 0.5 to 3.7 mGy and the average was 1.5 mGy, while the temporal guidance level proposed by IAEA was 3 mGy. From the answers in the questionnaire, it was analyzed that dominant causes of low image quality and high dose were improper selection of the instruments and materials such as grid and film screen system.

2.3. Central Committee for QA of Breast Cancer Mass Screening[9]

The Central Committee on Quality Control of Mammographic Screening was organized in cooperation with the six societies. These were Japan Association of Breast Cancer Screening, Japan Radiological Society, Japan Society of Obsterics and Gynecology, Japanese Society of Radiological Technology (JSRT), Japanese Breast Cancer Society and Japan Society of Medical physics (JSMP). The committee has two subcommittees. One is Committee for Education, which holds seminars on the interpretation for medical doctors and on radiographic technique for radiological technologists. Since 1999, about 20 seminars have been held in a year with about 50 participants in dominant cities in Japan. Those who passed the examination have been certified their skill and names of the person and the institution are indicated in the WWW site[10] of the Central Committee. The other is Committee for Quality Assessment, which evaluated the image quality (phantom image and clinical image) and patient dose in the institutions that applied the assessment since 2001. About 80% among 135 institutes satisfied the requirements of the protocol and certifications were issued. The average glandular dose ranged from 0.80 to 1.90 mGy and the average was 1.22 mGy, which were much lower than 3mGy, the IAEA's guidance level.

3. QA OF LUNG SCREENING CT

3.1. LUNG SCREENING CT

Lung cancer has been continuously increasing and has been the first cause of death in Japan since 1998. Though the mass screenings of lung has been performed by means of fluoroscopic radiography, it is difficult to detect a tumor smaller than 2 cm. The cure rate of lung cancer larger than 2 cm is very low because of metastasis. Japanese researchers proposed[11] the utilization of low dose CT to the effective screening. The Society of Thoracic CT Screening (TCS) was established in 1993 for the systematic investigation. By some pilot studies[12-14], it was found that the low dose scanning even less than that of fluoroscopic radiography could well detect nodules smaller than 2cm and epidemiologic analysis indicated that the net benefit of life saving would significantly increase. Low cost mobile CT units were developed and utilized in local mass screening for further studies. In this year, a cohort study to prove the effectiveness started for the introduction of LSCT to the nation wide mass screening.

By the trial use of LSCT in mass screening, it was found that low dose CT could detect not only lung cancer but also pulmonary emphysema. Moreover, not only in chest region, but also lesions in whole body such as renal cancer, lymphoma, aortic aneurysm, coronary stenosis and others[15]. Low dose CT mass screening is about to be expanded to whole body and popularized in to the world. In these circumstances, the researches on the optimization and QA of the low dose CT become very important.

3.2. Target lesion, image quality and patient dose

The required radiation dose depends on the target lesion. A higher image quality is required to detect ground glass lesions than solid nodules. A higher dose is required to detect lesions in mediastinum than in lung. If the target is whole body, a more dose is required. The optimization may depend on the target lesion of the screening.

Many technical factors influence to the image quality and patient dose such as tube current, filtration, slice thickness, table pitch and others. A systematic technique should be developed for the optimal determination of these factors according to the target lesions. After that, a guidance level should be determined for the mass screening.

3.3 Strategy to QA of LSCT

In 2000, Technical Committee was organized in TCS for the establishment of QC system and the publication of QC Manual. The basic concepts of the manual were as follows[16]: 1) The key words in the first step were "thoracic", "CT" and "primary and secondary screening". 2) The QC procedures should be clearly shared to medical doctors, radiological technologists, medical physicists and others. 3) The procedures should be classified into two categories, one those should be performed by the screening institution and the other those objectively performed by the third party. 4) Procedures should include necessary and sufficient items so that they were achievable in most institution for a long term but were done in a short time. (The 5th through 7th items were abridged.)

Like in the case of mass screening MMG, a QC center seemed to be organized. The manual is expected to be the background of the seminars and assessments performed by the screening institutions and the QC center.

4. QA OF INTERVENTIONAL RADIOLOGY

4.1. Radiation Hazard of Skin Caused by IVR

In 2001, reviews on skin injuries from fluoroscopically guided procedures were published[17-18], which included reports on 73 serious cases in United States. In Japan, more than ten cases were reported[18] in 2001. In addition, a television program reporting a case was critically broadcast to the public in Japan. This patient was not informed on the hazard. He consulted with a dermatologist, who was not familiar to radiation injury like other dermatologists, and it took a long time to find that it was radiodermatosis. The lesion progressed to ulcer and skin graft was required. Many other cases took similar prognosis. An earlier and appropriate treatment might much reduce the pain of the patients.

The ICRP publication 85 in 2001 [19] recommended that: 1) A standard time for fluoroscopy and number of radiography should be evaluated. 2) Interventionists should be educated on the radiation protection. 3) When the skin dose was near to 3 Gy, the site and the estimated dose should be recorded. 4) When the dose exceeded 3 Gy, the irradiated site should be inspected two weeks after. 5) The patient should be informed with the radiation hazard. In addition to the proper maintenance of equipment and training on the operation, we should predict the prognosis based on the dosimetry, prepare an appropriate treatment if necessary including skin graft, and explain them to the patient.

In October 2001, a conference on protection of IVR skin injury was held in cooperation with 14 associations of interventionists, radiologists, radiological technologists, medial physicists, dermatologist and others. All the attendee agreed on the importance of the informed consent and the dose estimation. A working group for the dosimetry was organized including medical physicists and radiological technologists.

4.2. Doisimetry in IVR

We should be aware of three kinds of dose: 1)Predicted dose before the operation 2)Real time dose increment during the operation 3)The total dose at hot spot for prediction of the prognosis. The methods and the required accuracy differ from one another. We, as medical physicists, should provide practical method for each.

For the cases in which the hot spot dose is approaching to or exceeding 3 Gy, the dose should be evaluated as accurate as possible. Some methods have been proposed[20-21] such as dose area product meter, skin dose monitor, TL dosimetry, low speed film dosimetry, CAREGRPH and others, each has, however, merits and demerits, respectively.

5. TRACEABILE SYSTEM OF DOSIMETERS FOR DIAGNOSTIC X-RAYS

5.1. Traceable system

The dosimetry is one of the most important factors in QC. We should use a dosimeter whose calibration factor is traceable to the national standard. There are more than 8000 hospitals in Japan, while there are only four laboratories that could supply a formal calibration with the traceability. In order to calibrate all the dosimeters once in two years, at least 100 calibration laboratories are required. JSMP and JSRT started a project to establish the traceable system of diagnostic x-ray dosimeters in Japan. The working group is now preparing, in the first step, 10 or more calibration laboratories in areas from Hokkaido to Kyushu.

5.2. Calibration System

The calibration laboratory should prepare a stable and accurate x-ray source, which have been too expensive for us to distribute them in each local area. However, recently in Japan, diagnostic x-ray units with inverter circuit have been rapidly popularized. By a survey by the project[22], it was found that the exposure reproducibility of inverter type diagnostic x-ray units was within 1% and, using them, many schools of radiological technology and hospitals were able to keep a reasonable accuracy. Sponsored by two Japanese manufacturers of dosimeters, twenty ionization chamber dosimeters of the two types were prepared for the reference dosimeters. In the next year, the accuracy and reproducibility of calibration in each laboratory will be evaluated and the calibration services will start.

REFERENCES

1. Kido C. et.al. Ann. Rep. Cancer Res. Minist. of Health and Welf. National Cancer Center 1992 p.p.300-305
2. Ohuchi N. et.al. Ann. Rep. Cancer Res. Minist. of Health and Welf. National Cancer Center 1996 p.p.282-287
3. "QA manual for Mammography" Japan Society of Radiological Technology 1996 Kyoto Japan
4. "Mammography Quality Control Manual" American College of Radiology 1994
5. Imamura K. et.al. J. Jpn. Assoc. Breast Cancer Screen. 6:271-279,1997
6. Katoh T. et.al. J. Jpn. Assoc. Breast Cancer Screen. 8:165-173,1999
7. Higashida Y. et.al. J. Jpn. Assoc. Breast Cancer Screen. 9:211-217,2000
8. Higashida Y. et.al. J. Jpn. Assoc. Breast Cancer Screen. 9:281-285,2000
9. Activity Report of The Central Committee on Quality Control of Mammographic Screening 2002

10. http://www.marianna-u.ac.jp/gakunai/jabcs/
11. Tateno Y. et.al. Inshin-Iryo 17(10):28-32,1990
12. Iinuma T. et.al. Nipp Acta Radiol. 52:182-190,1992
13. Iinuma T. et.al. Nipp Acta Radiol. 54:943-949,1994
14. Matsumoto M. et.al. Nipp Acta Radiol. 55:172-179,1995
15. Brent-Zawadzki M. Amer. J. Radiol. 179:319-326,2002
16. Matumoto T., Ito S, et.al. Thora. CT Screen. 8: 276-279,2001
17. Koenig T.R. Amer. J. Roentgenol. 177:3-11, and 13-20, 2001
18. Togshi A. News Letter of Jap. Assoc. Radiat. Protec. Med.
19. ICRP "Avoidance of Radiation Injuries from Medical Interventional Procedures" Pub. 85, 2001
20. Waite J.C. et.al. Radiat.Protec.Dosim. 94:89-92,2001
21. Toivonen M. Radiat.Protec.Dosim. 94:105-108,2001
22. Katoh T. et.al. Jpn. J.Radiol.Tecnol. 57(12):1438-1443,2001