Safety Management of Environmental Radiation Doses in and around the Nuclear Medical Inspection Room

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Abstract

Background/Objectives: The frequency of making nuclear medical inspections has increased all over the world. Accordingly, people have been increasingly concerned about radiation exposure by such inspections.

Methods/Statistical analysis: Using glass dosimeter, this study measured cumulative radiation doses in and around the inspection room equipped with nuclear medical inspection machines and the PET-CT inspection room, and analyzed exposure doses of patients and radiological technologists.

Findings: The dose in the lobby of the nuclear medical inspection room was 0.05 mSv for a month, 0.15 mSv for 3 months, and the dose on the door of the waste storage room was 0.11 mSv for a month, 0.33 mSv for 3 months. The dose on the door of the pollution inspection room was 0.08 mSv for a month, 0.24 mSv for 3 months. The environmental doses around the gamma inspection room and around the nuclear medical inspection room were not above natural radiation dose. The dose for 3 months on the door of the stability room where patients injected with isotope wait for some time before entering the PET-CT room was 0.33 mSv. And, the annual dose at the place would be 1.32 mSv. The doses around the PET-CT room and the PET-CT reception and waiting room were measured as below the natural radiation dose.

Improvements/Applications: The findings of this study seem to show that, to do optimized medical radiation safety management, Korea needs to adopt the degree management specialist and establish the legal system requiring hospitals to periodically measure environmental doses and do safety management.

Keywords: PET-CT inspection, isotope, environmental radiation dose, medical radiation, dosimeter

1. Preface

Nuclear medical science is a part of medical science which objectively identifies functions or bio-chemical responses of each organization and tissue of human body, and diagnose, evaluate, and treat diseases, if any, using radionuclide. Nuclear medical inspections have increased over time around the world. Currently, in Korea, about 920,000 nuclear medical inspections and treatments are made a year. With increase of such inspections, people have become more concerned about radiation exposure caused by them.

Radioactive isotopes used in nuclear medical inspections are used by leveling radioactive isotopes on various compounds. Before being administered to the patient, a radioactive isotope is radiation, but, after it is administered to the patient, the whole body of the patient becomes radiation. When medical radiation is used, it should secure justification and optimization [1-2]. The total benefits acquired by using medical radiation include not only what the patient directly gets, but also what the family members of the patient and the society get. Medical radiation exposure is concerns of the patient, first of all. But we should be also concerned about the effects of the exposure to radiological technologists, care-givers, and family members of the patient [3-6].

Nuclear medical inspection has settled down as an essential procedure to precisely diagnose and predict diseases in the clinical part. But, as the inspection uses radioactive isotopes, people are concerned about risks of radiation exposure to their health [7-9].

Radiological technologists dealing with diagnostic radiation receive personal exposure dose management by the Medical Law, and those technologists using radioactive isotopes and radioactive treatment equipment are under safety management by having personal exposure doses measured based on the Nuclear Safety Act. Personal exposure dose is measured by ThermoLuminescence Dosimeter (TLD) or glass dosimeter. Personal exposure dose is managed by evaluating total exposure doses per quarter[10-13].

In the process of making diagnostic radiation inspection and nuclear medical inspection, the exposure dose of common people who are not targets of justification should be managed not to exceed 1mSv per year[14-16].

The provisions on hospital environment dose management in the Medical Law designates that the leakage radiation in the zone of radiological technologists should be 100 mR or less per week, and that in the residential area of common people should be 100 mR or less per week. However, in hospitals, it is measured only in the first inspection after the defensive facilities are installed.

This study was performed to provide dose management data in making policies on safety management of medical radiation by measuring the accumulated dose using glass dosimeter on the outer wall, door, and patient observing window of the inspection room where the apparatuses for nuclear medical inspection including positron emission tomography (PET), and comparing accumulated doses of radiological technologists and common people living outside of the hospital.

2. Experimental sources and method

2.1. *Measurement of environmental dose around the nuclear medical inspection room*

To measure environmental radiation dose around the nuclear medical inspection room, this study chose D hospital which performs on average 300 or more nuclear medical inspections for a month, and measured environmental radiation doses for one month from January to February, 2020. Measured accumulated environmental radiation doses were analyzed using the Glassbadge(GB) RS type manufactured by Chiyoda Technol Co. of Japan [Figure 1].

Measurement of natural radiation and background was done in an office of the same hospital building which is near the inspection room, but is not affected by medical radiation by installing 2 glass dosimeters. The dose measured in this method was used as the background reference value.

Nuclear medical inspection room is managed by being designated as radiationcontrolarea. The measurement of environmental radiation dose was done at the position of 170 - 190cm above the floor at nuclear medical reception room and its lobby, gamma camera inspection room, waste storage room, door and barrier wall, glass barrier wall, inspection room space [Figure 2].

Figure 1. Glass dosimeter to measure environmental dose

Figure 2. The position of glass dosimeter to measure environmental radiation dose

2.2. ***Analysis of environmental radiation dose of PET-CT inspection room***

To measure environmental radiation dose around the PET-CT inspection room, this study selected D Hospital which does more than 300 PET-CT inspections for a month, and measured environmental radiation dose for one month from January to February, 2020.

The PET-CT room is under the regulation of both the Medical Law and the Nuclear Safety Act. The environmental radiation doses around the PET-CT room were measured on the inside and outside of the doors of the reception and waiting room, the isotope distribution room, and the stabilization room. The environmental radiation doses at the PET-CT room were measured on the inside and outside of the door, the barrier wall, and the lead glass. The position of glass dosimeter to measure environmental radiation dose was 170 - 190cm above the floor [Figure 3].

Figure 3. The PET-CT inspection room

The results of measurement were sent to the Chiyoda Technol Co. to be analyzed. The doses of environmental radiation accumulated for one month were calculated for three months to compare results on different places. Loss of background when the dosimeters pass the X-ray inspection was corrected with the measured values of standard dosimeters.

3. Discussion on research results

3.1. ***Environmental radiation doses around the nuclear medical inspection room***

The nuclear medical inspection room is managed by being designated as the radiation control area based on the Nuclear Power Safety Act. The radiation control area is the area where external radiation dose is 400 μSv over per week, and it is advised to take measures to deal with it.

It is recommended that the effective radiation dose of medical staff dealing with radiation should not exceed 50 mSv a year, neither should 100 mSv for five years. It is also recommended that the effective radiation dose of those who occasionally visit radiological facilities and that of those who deliver supplies should not exceed 12 mSv a year.

The radiation doses on the door and on the barrier wall of the inspection room using gamma camera did not exceed natural radiation dose. The radiation dose on the glass protection wall protecting radiation worker inside the inspection room did not exceed natural radiation dose as well.

The radiation dose inside the waste storage room was 0.16 mSv for a month, and the cumulative dose for three months was 0.48 mSv. The environmental dose on the door of the room was 0.11 mSv, with 0.33 mSv for three months. The environmental dose on the barrier wall of the waste storage room did not exceed natural radiation dose.

The radiation dose inside the pollution inspection room was 0.06 mSv for a month, and the cumulative dose for three months was 0.18 mSv. The environmental dose on the door of the room was 0.08 mSv, with 0.24 mSv for three months. The environmental dose on the barrier wall of the pollution inspection room did not exceed natural radiation dose.

In the nuclear inspection reception room, radiation dose exceeding natural radiation dose was not detected. The radiation dose at the lobby of the inspection waiting room was 0.05 mSv for a month, 0.15 mSv for three months[table 1].

In Japan, radiation safety management in the nuclear medical inspection room is done according to Article 30 of the Enforcement Rules of the medical Law, Article 20 of the Enforcement Rules of the Radiation Damage Prevention Law, and Article 54 of the Enforcement Rules of the Labor Safety Law and the Ionizing Radiation Prevention Law. The radiation doses in and around the facilities using radiation and pollution caused by radioactive isotope are measured once a month or more, recorded, and stored for 5 years.

In Korea, it is required that the exposure doses of radiological technologists be measured, and there are limits on the cumulative doses of them. The Nuclear Power Safety Law and the Rules on Safety Management on Diagnostic Radiation Generator prescribe effective annual dose limits of 50 mSv for radiological technologists, and 100 mSv for 5 years for them, and effective annual dose limits of 1 mSv for common people.

The cumulative dose for 3 months measured at the door of the waste storage room was 0.33 mSv, and the annual dose would be 1.32 mSv. The annual dose at the door of the pollution inspection room was 0.96 mSv, and the annual dose inside the reception and waiting room was 0.60 mSv.

As the employees in the reception room and patient protectors are not related with nuclear medical treatment, there should be measures that their exposure doses not exceed the annual limit for common people 1 mSv. Accordingly, there should be safety management the annual exposure doses around the waste storage room should be below 1 mSv.

Table 1: Environmental radiation doses in the nuclear medical inspection room (Unit: mSv)

Measurement place		1 month (mSv)	3 months (mSv)
Gamma Camera Room	**Lead glass**	**-**	**-**
	Door	**-**	**-**
	Barrier wall	**-**	**-**
Waste Storage Room	**Door**	**0.11**	**0.33**
	Barrier wall	**-**	**-**
	Inside the room	**0.16**	**0.48**
Pollution Inspection Room	**Door**	**0.08**	**0.24**
	Barrier wall	**-**	**-**
	Inside the room	**0.06**	**0.18**
Nuclear medial Reception Room and Lobby	**Reception room**	**-**	**-**
	Waiting room	**0.05**	**0.15**

3.2. *Environmental doses in and around the PET-CT inspection room*

According to related laws in Korea, PET-CT inspection room should be managed by dividing it into radiation management zone and radiation zone. It is because of the fact that it is the place where computerized tomography images needed for diagnosis are acquired using radioactive isotope.

The Rules on Technology Standards Including Radiation Safety Management based on the Nuclear Power Safety Law prescribes that the place where external radiation dose is 400 μSv(0.4 mSv) over per week should be managed by designating it as Radiation Management Area. and, the Rules on Safety Management of Diagnostic Radiation Generator based on the Medical Law prescribes that place where external radiation dose is 0.3 μSv(0.4 mSv) over per week should be managed by designating it as Radiation Area.

The radiation doses in and around the PET-CT inspection room were as follows. The cumulative dose in the inspection room for 3 months was 5.01 mSv. Theannual dose would be 20.04 mSv. The doses at the door and outside the barrier wall were measured as being below natural radiation dose. Such findings show that, while the dose inside the PET-CT inspection room exceeds the annual limit of radiation dose, radiation doses around the room are safely managed using barrier wall and barrier objects and proper distance from the radiation source.

The stability room is the place where patients who are injected with isotope wait to be PET-CT tested. The cumulative dose for 3 months on the door was 0.33 mSv. So, the annual dose would be 1.92 mSv. The corresponding value inside the room was 0.48 mSv, and the annual value would be 1.92 mSv. The doses outside the barrier wall and the reception and waiting room were found to be below natural radiation dose. Such findings show that, while the dose inside the PET-CT inspection room exceeds the annual limit of radiation dose, radiation doses around the room are safely managed using barrier wall and barrier objects and proper distance from the radiation source[table 2].

Table 2: Environmental doses in and around the PET-CT Inspection Room (Unit: mSv)

Measurement place		1 month (mSv)	3 months (mSv)
PET-CT Inspection Room	Lead glass	-	-
	Inside the door	-	-
	Inside the barrier wall	-	-
	Outside the door	-	-
	Outside the barrier wall	-	-
	Inside the room	1.67	5.01
PET-CT Stability Room	Door	0.11	0.33
	Barrier wall	-	-
	Dose inside the room	0.16	0.48
PET-CT Reception and Waiting Room		-	-
Isotope Distribution Room	Door	-	-
	Protection wall	-	-
	Dose inside the room	0.07	0.21

The doses in and around the isotope distribution room were as follows. The cumulative dose for 3 months inside the room was 0.21 mSv. So, the annual dose would be 0.84 mSv. The doses at the door and outside the barrier wall were found to be below the natural radiation dose. Such findings show that, while the dose inside the isotope distribution room exceeds the annual limit of radiation dose, radiation doses around the room are safely managed using barrier wall and barrier objects and proper distance from the radiation source.

The average annual exposure doses among radiological technologists in different countries are as follows: 0.45 mSv in Korea, 0.32 mSv in Japan, 0.06 mSv in Canada, and 0.05 mSv in Germany.

While the average annual exposure dose among Korean radiological technologists 0.45 mSv is only about 1/40 of 20 mSv, the limit of allowed annual dose, the value is much higher than the corresponding values in countries advanced in managing medical radiation. Thus, it is necessary to adopt the systems and measurement methods used by those advanced countries[17-20].

In Japan, the related law revised in 2001 requires that the medical centers using nuclear medical inspection facilities should install glass dosimeters and evaluate cumulative doses for 3 months. Those in charge of diagnostic radiation dose should report cumulative doses for 3 months every 6 months. Nuclear medical inspection facilities and radiation treatment facilities are managed with the data acquired by measuring doses at least once for a month.

Canada applies a system called the radiation generator degree management specialist (QC technologist). The system requires the hospital with 500 beds or more to hire one QC technologist, and the hospital with less than 200 beds to hire QC technologist who allots half of his or her working time to the hospital.

In Korea, to manage medical radiation safely, it seems necessary to adopt the QC technologist system, and establish the legal system requiring hospitals to periodically measure environmental radiation doses. And, it also seems necessary to continue to do researches on safety management of medical radiation.

4.Conclusion

This study measured and analyzed environmental radiation doses in and around the nuclear medical inspection room and the PET-CT inspection room.

The dose in the lobby of the nuclear medical inspection waiting room was 0.05 mSv for a month, 0.15mSv for 3 months. The environmental radiation dose at the door of the waste storage room was 0.11 mSv for a month, 0.33 mSv for 3 months. The environmental radiation dose at the door of the pollution inspection room was 0.08 mSv for a month, 0.24 mSv for 3 months. The doses around the gamma camera inspection room, and around the nuclear medical inspection room were not above natural radiation dose.

The cumulative dose for 3 months at the door of the stability room where patients are injected with isotope for some time before entering the PET-CT room was 0.33 mSv, and the cumulative dose for one year was 1.32 mSv. The doses around the PET-CT room, and the PET-CT reception and waiting room were found to be below the natural radiation dose.

It is expected that the findings of this study will be used as the sources for establishing policies on safety management of medical radiation, and for performing safety management in hospitals. This study proposes that there should be continuous researches on measurement of radiation doses in and around the nuclear medical inspection rooms in all the medical institutions in Korea and on safety management policies.

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