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# An Evaluation of Environmental Doses of Inspection Room of Angiography and Interventional Therapy

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**Abstract**
Angiography is the most accurate method among vascular inspection methods. As angiography allows one to figure out the overall form of blood vessel and the degree to which it is clogged, it is essential to diagnose and treat vascular diseases like stroke, myocardial infarction and others.This study measured and analyzed spatial dose and integral dose by using environmental glass dosimeter at outer wall, door, patient-watching window (lead glass) of the inspection room where angiography and vascular interventional therapy equipments are used.At the door of the x-ray generator control room, dose exceeding the natural radiation dose in the whole hospital was detected, with maximum leaked dose 3.30 mSv, minimum leaked dose 0.24 mSv, and mean leaked dose 0.89 mSv. Radiation leakages at the wall of control room, at the entrance door and wall of inspection room were not over natural radiation does. Spatial integral doses in the computer control space supporting and recording therapy and inspection were measured as 1.05 mSv, 0.36 mSv at the distance of 3m from X-ray tube. Spatial integral doses before penetrating the patient-watching window were measured as 2.37 mSv, 0.54 mSv, 2.07 mSv, 0.78 mSv, 0.00 mSv, 3.30 mSv, with mean dose 1.51 mSv. The shielding effectiveness of the patient-watching window was on average 96%.Such research findings are expected to serve as meaningful reference data in suggesting safety management policies and implementing safety management in clinical conditions.

**Keywords:** leakage radiation dose;lead glass (patient-watching glass); angio room; intervention; glass dosimeter

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## Preface

In medical field, radiation has increasingly been used with the development of medical

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technology, because of its usefulness in diagnosing diseases and corresponding benefits to patients, despite the risks it can cause cataract or cancer.

Angiography is the technique of inspecting blood vessel using the fact that when contrast media is inserted in blood vessel like cerebral artery or coronary artery, the vessel can be clearly observed. As this method allows one to observe the overall figure of blood vessel and the degree it is clogged the most accurately, it is essentially used to diagnose and treat vascular diseases like stroke and myocardial infarction (Jeong W K., 2011; Kim DH. *et al.*, 2017).

Unlike the general radiation inspection for diagnosis, interventional procedure can involve projecting radiation for long time and angiography several times. Thus, it is unavoidable that patients are more likely to be exposed to the risk of being damaged by the procedure (Bak H.*et al.*, 2014; Park C W.*et al.*, 2019)

In addition, interventional procedure leads to various exposure doses depending on various variables such as patient and lesion conditions, difficulty of the therapy, precision therapy or not, condition of shooting equipment, and technique and skillfulness of therapist. Actually, researches have reported that radiation exposure doses vary per country and per hospital. The number of patients who receive cardiovascular angiography has rapidly increased during the past decade with the development of digital radiation equipments and devices. For a patient who is under cardiovascular angiography, as the same area is exposed to radiation for a long time, it can be exposed to a large amount of radiation dose, causing skin radiation damage (YoonH J. *et al.*, 2019; Kim J S.*et al.*, 2016; HanS C. *et al.*, 2016).

According to the Korean rules on safety management of diagnostic radiation generators, the sum of leakage radiation dose and scattered dose measured outside of the protection wall should be lower than 100 mR (2.58 × 10-5 C/kg)/week (Kim C G., 2020).

It has been reported that the number of radiation-related workers, kinds of equipments, the amount of energy and operation rates used by equipments per week vary in different hospitals. While in principle radiation-related workers should be outside of the protection wall and the door of the control room, such a rule can cause problems like narrowing the vision of radiation-related worker, and blocking the communication between the worker and patient, reducing the responsive capacity of the worker to a crisis. Plus, continuous opening and closing the door can delay the inspection time, reducing the work efficiency. Thus, it has been reported that there are cases where the door of the control room is left open to prevent or respond rapidly to unexpected emergencies and to improve work efficiency (KimC G., 2016; JooY C., 2014; Jeong W K., 2011).

Most of the researches on management of radiation dose are about development of technology to reduce exposure doses of radiation-related workers or patients. And, there has been no research on safe management of dose through measurement of leaked environmental radiation. To measure

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leaked environmental radiation, the method of measuring dose at an instant, and converting it into the amount of dose per week is usually used. But, it is hard to say that the values acquired from this method exactly match those emitted by medical facilities. To accurately measure leaked dose of the facilities using medical radiation, it is advised that it is essential to measure cumulative dose leaked real time.

This study was done to provide the data on safe management of medical radiation by measuring and evaluating cumulative dose using environmental glass dosimeter at the outer wall, door, patient-watching window of the inspection room which uses angiography and interventional therapy equipments.

## Experimental materials and method

### Measurement of environmental dose of the inspection room where angiography and vascular intervention are done

To measure environmental dose at the border of the radiation zone, this study selected 6 hospitals of the scale of university hospital where vascular angiography and interventional therapy are conducted simultaneously (Kim C G., 2020). To measure environmental integral dose in the inspection room of angiography and vascular interventional therapy and the border of the inspection room, this study used glass dosimeter which is good in linearity, reproducibility, and preciseness, and is possible to be repeatedly analyzed. As glass dosimeter, this study chose Glassbadge (GB) RS type for environmental use produced by the Japanese maker (千代田テクノル).

Environmental dose and background dose at the border of radiation zone were measured by one-month integral dose and the values were converted into those of three months. To evaluate natural environmental dose and analyze exposure dose of medical radiation, this study installed environmental glass dosimeter and measured background at the space which was not affected by medical radiation in the same building where medical radiation was measured [Figure 1].

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**Figure 1: Environmental glass dosimeter to measure background**

Environmental glass dosimeters at the border of the radiation zone were installed at the entrance door, protection wall of inspection room where radiation-related workers, common people, and patients can enter, and the entrance door and protection wall of control room where radiation equipments are installed. Those dosimeters were placed 170- 190cm above the floor [Figure 2].

**Figure 2: The location of glass dosimeter to measure environmental dose**

**Patient-watching window of the inspection room of angiography and intervention and spatial dose measurement and dose analysis**

Cumulative doses of patient-watching window were measured inside and outside of patient-watching window at the places which were not blocking the movement of radiation-related workers, but allowed one to efficiently measure dose, and where medical persons recording dosimeter values [Figure 3].

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**Figure 3: The location of glass dosimeter to measure spatial dose**

To analyze shilding effect of patient-watching window, this study installed dosimeters inside and outside of the window, and tested whether the difference of values inside and outside of the window is statistically significant. To compare measurement values with those of foreign researches, this study converted the integral dose of 1 month to that of 3 months. To secure objectivity of measurement results, this study used the dosimeter produced by the abovementioned Japanese company and referred it to analyze measurement results (Kim C G., 2020).

**Statistical treatment and analysis**

To statistically analyze measurement results, this study used SPSS version 24.0 (Statistical Package for the Social Sciences, IBM Co., Chicago, USA). Using paired t test considered to be conservative statistical method, this study set confidence interval 95% and judged that less than p-value .05 is statistically significant. to measure significant differences of groups per situation.

**Findings and discussion**

**Spatial doses and environmental doses of Angiography and intervention inspection room**

To measure angiography and intervention, this study used the digital X-ray equipment which can take 3-D images of blood vessel. The distance between the X-ray tube and the flat panel detector was 1200 mm, and the diagonal length of the flat panel detector was 420 mm. To measure the conditions like tube electric current, tube voltage, and radiation time, etc., this study used AEC (Automatic Exposure Control), and the range of tube voltage was 70~125 kV.

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**Table 1: Leaked doses at the border of angiography and intervention inspection room(unit: mSv)**

| Hospital | Door of control room | Wall of control room | Entrance Door | Entrance wall |
|---|---|---|---|---|
| 1 | 0.24 | - | - | - |
| 2 | 3.30 | - | - | - |
| 3 | 1.23 | - | - | - |
| 4 | 0.24 | - | - | - |
| 5 | 0.30 | - | - | - |
| 6 | 0.57 | - | - | - |
| Mean | 0.89 | - | - | - |

When angiography and interventional procedure were performed, the exposure dose of radiological technologist was the highest at AP view among the angles from X-ray tube. As FOV is expanded, dose increased up to 1.2-1.6 times, and as the longer the distance between X-ray tube and flat panel detector got from 100mm, the higher dose got by 20-30%. And, the shorter the distance between X-ray tube and table, the higher dose got by 10%.

Currently, the number of angiography has strikingly increased from the past. What is mainly used as medical radiation is X-ray generator. Scattered dose and leaked dose from the generator increase the exposure dose of radiation-related workers. To reduce the exposure dose of them, it is necessary to apply proper shielding apparatus and countermeasures.

Among the doses measured at the places around the inspection room where angiography and intervention are performed, the value of dose at the door of control room was higher than that of natural radiation dose. The range is from the maximum leaked dose 3.30 mSv, to the minimum dose 0.24 mSv, with the mean 0.89 mSv. The values of leaked dose at the wall of control room, and entrance door and wall of inspection room were similar to that of natural dose [Table 1].

The reason why the leaked doses at the control room door when angiography and intervention are performed are the same as scattered radiation dose seems from the fact that such radiation procedures are done with the door open to respond quickly to crisis, instead of closing the door of control room.

The reason why dose was not detected from the wall of control room, entrance wall and

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entrance door seems to be caused by the fact that X-ray is projected only to patients, and technologists served as a kind of shielding walls, and absorbing part of scattered dose.

Spatial doses at the computer adjustment space which supports and records therapy and inspection in the inspection room of angiography and intervention were measured as 1.05 mSv, 0.36 mSv at the distance of 3m from X-ray tube [Table 2]. Some hospitals support angiography and intervention in inspection room. The findings of this study demonstrate that technologists should wear personal dosimeter and take measures to reduce exposure dose.

**Table 2: Spatial doses in the computer adjustment space in the inspection room of angiography and intervention (unit: mSv)**

| Hospital | Spatial cumulative dose | Distance from X-ray tube |
|---|---|---|
| 1 | 1.05 | 3m |
| 2 | 0.36 | 3m |

In this experiment, glass dosimeters were installed in and around inspection room at the height of 170-190cm above ground and measured doses for 1 month. By multiplying the measured values by three, this study got the cumulative doses for 3 months to match the values with other of Japan, 1.3mSv per 1cm dose. It was found that does of one hospital exceeded the values of Japan. The hospital whose dose values exceeded japanese values wasacceptable to the Korean criteria as weekly load.

The finding seems to indicate that the medical radiation dose management set as weekly load has some limits. This study wants to suggest that, like the case of Japan, setting a integral dose during a certain period of time as criterion is a safer and more systematic management method of medical radiation safety.

### Spatial dose and environmental dose at patient-watching window of inspection room of angiography and intervention

According to the Korean rules on safety management of radiation generator for diagnosis, if the highest tube voltage exceeds 100KV, lead equivalent should be over 1.5mm at patient-watching window, and, if the highest tube voltage is 100KV or less, lead equivalent should be over 1.0mm at patient-watching window.

Tube voltage used in the inspection room of angiography and intervention is about 70-

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125kV. As the maximum tube voltage is over 100kV, lead equivalent should be over 1.5mm. Therefore, all the medical centers using angiography and intervention radiation generators should be equipped with patient-watching window of 1.5mm or over.

This study, with the aim of testing shielding functions of patient-watching window used in the inspection room of angiography and intervention, and using the data as the bases of safety management, measured and analyzed environmental radiation of patient-watching window in and out of the room equipped with diagnostic radiation generators

Spatial cumulative doses before penetrating patient-watching window in 6 hospitals were 2.37 mSv, 0.54 mSv, 2.07 mSv, 0.78 mSv, 0.00 mSv, and 3.30 mSv, with the mean dose being 1.51 mSv.

The average shielding efficiency of patient-watching window in the inspection room of angiography and intervention in 6 hospitals was 96%. In five out of six hospitals, dosimeter outside of the window did not show doses exceeding natural radiation dose. Only one hospital recorded leaked dose 0.36 mSv[Table 3].

**Table 3: Spatial dose and leaked dose at patient-watching window of inspection room of angiography and intervention(unit: mSv)**

| Hospital | Patient-watching window in the room | Patient-watching window outside of the room | Shielding rate (%) |
|---|---|---|---|
| 1 | 2.37 | 0.36 | 84.8 |
| 2 | 0.54 | - | 100 |
| 3 | 2.07 | - | 100 |
| 4 | 0.78 | - | 100 |
| 5 | - | - | 100 |
| 6 | 3.30 | - | 100 |
| Mean | 1.51 | 0.06 | 96 |

Such findings seem to show that environmental radiation doses showed different results by energy, weekly operation amount of X-ray generator in the inspection room of angiography and intervention, and geometric structural environment. And, the results show that shielding

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efficiencies of patient-watching window are not equal in all hospitals. Shielding efficiencies may have decreased because of long use, and increase of fatigue by oxidization. Thus, it is necessary to adopt an institution to periodically check and certify shielding efficiencies of patient-watching window in Korean hospitals.

This study measured cumulative integral doses for one month, and had difficulty in choosing hospitals and getting cooperation from the hospitals because of the maintenance of dosimeters and negative images on measurement results. Thus, this study had no choice but to choose hospitals in a certain region. So, it has problems to generalize the findings of the analysis. To overcome such limits, future studies need to use medical centers all across the country, and continue to do researches on leaked doses of protection facilities of diagnostic radiation and on materials and shielding efficiency of patient-watching window.

## Conclusion

This study measured and analyzed spatial dose and integral dose at the outer wall and door, and patient-watching window in the inspection room of angiography and intervention using environmental glass dosimeter.

Among doses measured around the inspection room of angiography and intervention, the dose at the gate of control room was over natural radiation dose with maximum leaked dose 3.30 mSv, minimum leaked dose 0.24 mSv, and mean dose 0.89 mSv. The doses of wall of control room, entrance wall and door of inspection room werenot different from natural radiation doses.

Spatial doses at the computer adjustment space in the inspection room of angiography and intervention were measured as 1.05 mSv, 0.36 mSv at the distance of 3m from X-ray tube. Spatial cumulative doses at patient-watching window inside the inspection room of angiography and intervention in 6 hospitals were 2.37 mSv, 0.54 mSv, 2.07 mSv, 0.78 mSv, 0.00 mSv, 3.30 mSv, with mean dose 1.51 mSv. Shielding efficiency of the window was on average 96%.

Such findings are expected to be meaningful reference data in making medical radiation safety policies and clinical practices. It is desirable that future studies will continue to deal with doses of protection walls, and the changes of shielding efficiency and materials depending on use period, not in some hospitals, but in all the medical centers in the country.

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