

Practical Radiation Protection for Interventional Radiologist

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Abstract

As per the International Commission on Radiological Protection 2010 recommendation, it was stated that “interventional radiologists performing difficult procedures with high workloads may be exposed to high doses” and that education and training of medical staffs in radiation exposure is “an urgent priority.” There are many reports on the textbook aspects of radiation protection, but reports on the practical aspects of radiation protection have remained to be scarce. Various methods of reducing radiation exposure are described as “useful” or “can be reduced,” but the priority of these methods and the “extent” to which they contribute to reducing radiation exposure are not clear. Thus, in this article, we will look into the protection of interventional radiologist from radiation exposure in a practical way, giving priority to clarity rather than academic accuracy.

Key words: radiation protection, occupational exposure, radiation exposure

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Introduction

Some interventional radiologists declare that “I am exposed to radiation at my own risk” and don’t care about high dose radiation exposure. Interventional radiologists in leadership positions must ensure that radiation protection is strictly enforced for the young doctors under their supervision. Leaders should not be allowed to teach interventional radiology techniques to their young subordinates based on massive radiation exposure, declaring that they are exposed at their own risk.

There are many reports on the textbook aspects of radiation protection, but few reports on its practical aspects. Various methods of reducing radiation exposure are often described as “useful” or “can be reduced,” but the priority of these methods and the “extent” to which they contribute to reducing radiation exposure are not clear. Thus, in this article, we will look into how interventional radiologist can protect themselves from radiation exposure in a practical way, giving priority to clarity rather than academic accuracy.

We Are Exposed to High Radiation Doses

How much radiation are we exposed to during interventional radiology? According to various reports, the dose rate within 50 cm of the X-ray tube can reach 1-10 mSV/h [1]. This dose rate is comparable to the dose rate in front of the main gate of the Fukushima Daiichi Nuclear Power Plant immediately after the explosion of all four nuclear power plant buildings during the Great East Japan Earthquake.

In the case of direct exposure to radiation by placing the hand in the X-ray fluoroscopy field, the dose rate can reach hundreds to thousands of mSV/h [1]. This dose rate is comparable to the high dose rate area in the building of Unit 1 of the Fukushima Daiichi Nuclear Power Plant 1 month after the nuclear accident.

The International Commission on Radiological Protection (ICRP) 2010 recommendation [2] states that “interventional radiologists performing difficult procedures with high workloads may be exposed to high doses” and that education and training of medical staffs in radiation exposure is “an urgent

priority.”

Never Put Your Hand in the Fluoroscopy Field: Direct and Scattered Radiation

Interventional radiologists are usually exposed to “scattered radiation.” X-rays are emitted from a tube, pass through the patient’s body, and are received by a detector. During this process, the X-rays are scattered, mainly by the patient’s body, and the interventional radiologist is exposed to the scattered X-rays. Scattered radiation exposure is “like holding your hand near water coming out of a tap,” with only a small portion of the radiation repelling and dampening the skin (Fig. 1).

On the other hand, if your hand is visible on the fluoroscopy screen, you are exposed to “direct radiation.” Direct radiation exposure is “like touching water directly from a tap” and thus soaked with radiation. If you put your hand inside the fluoroscopy screen, you are directly exposed to the X-rays emitted by the tube. Direct radiation has a much higher dose than scattered radiation. Scatter radiation is in the order of micro sievert/minute, while direct radiation is in the order of mSv/minute [3]. Even a short exposure to direct radiation can result in a dose of several mSv. In Japan, a case of skin cancer at the site of exposure has been reported in a doctor who had been exposed to direct X-rays during a procedure [4].

The most basic and important aspect of radiation protection for the interventional radiologist is to avoid direct radiation exposure. Surgical gloves containing lead are available on the market, but they are only intended to protect against scattered radiation, and when lead enters the X-ray field, the X-ray machine automatically adjusts to the conditions and increases the dose.

Understand Where the Scattered Radiation Comes from: The Source of the Operator’s Exposure Is the Skin Surface of the Irradiation Field

Unless a hand is inserted into the fluoroscopic field, the interventional radiologist’s exposure is entirely due to scattered radiation. The source of the operator’s exposure to scattered radiation is the skin surface of the patient’s irradiation field, with scattered radiation coming from both the patient’s skin on the tube side and the detector side.

The scattered radiation generated from the skin surface of the irradiation field on the side of the X-ray tube is called “back-scattered radiation” and is the image of radiation emitted from the X-ray tube hitting the patient’s skin and bouncing directly back. They are much more intense than “forward-scattered radiation,” with a dose about 20 times higher. In the under-tube system used in conventional interventional radiology (X-ray tube under the patient’s table), the back-scattered radiation is exposed below the surgeon’s

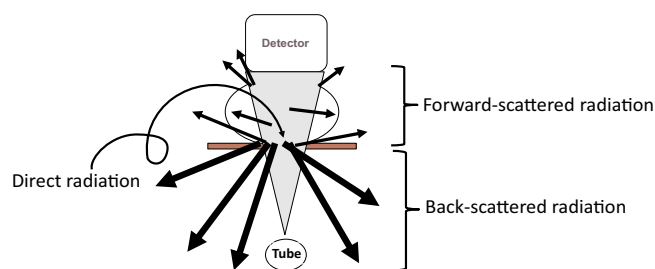


Figure 1. Direct, Forward-scattered and back-scattered radiation.

Direct radiation is emitted from the tube to the patient. The direct radiation is scattered by the patient or other objects and becomes “scattered radiation,” which exposes the surrounding area to radiation.

Back-scattered radiation has a higher dose than forward-scattered radiation.

waist and is often not assessed by personal dosimeters (Fig. 1).

The scattered radiation generated from the skin surface of the irradiation field on the detector side is called “forward-scattered radiation,” which is the image of radiation that has passed through the patient’s body and is attenuated and is finally scattered on the patient’s skin surface. Forward-scattered radiation mainly exposes the upper body of the interventional radiologist in under tube devices.

It is a common mistake to see a situation where the surgeon is standing on the side of the X-ray tube during lateral fluoroscopy and is thus exposed to intense backscatter. This is often misunderstood by the uninitiated as “standing on the receiver side increases the radiation exposure as it is directed toward the operator.” It is important to note that this is a common misconception. The correct statement is: “During lateral fluoroscopy, the surgeon should stand on the detector side.”

The setting should be such that the radiation is directed toward the operator. Standing on the detector side allows the surgeon to be exposed to only forward-scattered radiation without being exposed to intense back-scattered radiation.

Appropriate Shield Placement: The Scattered Radiation Source Is Confirmed

If it is understood that the “patient skin surface of the irradiation field” is the scattering source, appropriate shielding is possible. Please confirm the shielding arrangement in the reader’s facility about the following points. Shielding is very effective and can reduce the scattered dose by about 1/100 when used properly [1].

1. Shields under the patient table

Is the shield installed in the shape of a curtain under the patient table arranged so that backscatter radiation can be shielded? If the shield is placed so that the skin surface of the irradiation field on the tube side is not visible when

viewed from the operator's lower leg, it is an appropriate placement. I have seen many facilities where these shields are placed on the foot side, which has nothing to do with shielding the back-scattered radiation because the shields get in the way when the table is moved.

Although the operator's lower body is exposed to intense back-scattered radiation, the usual sites for wearing personal dosimeters are the head and neck and the chest or abdomen. For this reason, many beginners are not aware of the intense back-scattered radiation exposure to the lower body.

2. Ceiling-mounted shields and detectors

The proper placement of the ceiling-mounted shield and detector is the shielding technique that requires the most skill during an interventional radiology procedure. Depending on the circumstances of the procedure, the operator must position the ceiling-mounted shield and detector appropriately to shield the forward-scattered radiation generated from the patient's skin surface on the detector side.

The detector, as a shielding element, is capable of shielding the forward-scattered radiation. Therefore, it is important to place the detector as close to the patient as possible without affecting the procedure. In situations where the detector is sufficiently close to the patient, the forward-scattered radiation flies through the gap between the patient's skin and the detector toward the operator.

The ceiling-mounted shield should be placed between the detector and the operator so that it can shield the forward-scattered radiation coming from the gap between the patient skin and the detector. Adequate positioning of the ceiling-mounted shield also allows for a sufficient distance of the operator from the irradiation field.

The excuse of the unconcerned beginner is that the ceiling-suspended movable shield will interfere with the procedure, but whether or not the ceiling-suspended movable shield is used sufficiently during the procedure makes a significant difference in the operator's radiation exposure. It is important that the instructor educates the novice surgeon in the proper placement of the shield during the procedure, as he or she is often immersed in the procedure. Many beginners are often careless about radiation exposure, especially when performing special or emergency procedures.

Compared to Fluoroscopy, the Radiation Exposure during Angiography Is More Intense: Hand Injection Is Strictly Prohibited

Many beginners in interventional radiology become so absorbed in the interventional radiology procedure that they find it troublesome to connect the catheter to the auto-injector. However, the radiation dose during angiography is much more intense than that of fluoroscopy; thus, the operator is exposed to a large amount of scattered radiation. Depending on the settings of the equipment, doing hand-injection angiography once can result in radiation exposure

to the operator equivalent to several tens of minutes of fluoroscopy. Even if care is taken to protect the operator from radiation exposure in other situations, all the effort will be lost if hand-injection angiography is done carelessly.

Consideration Should Also Be Given to the Radiation Exposure of Medical Staff

The interventional radiologist can sufficiently reduce radiation exposure by using a ceiling-mounted shield and a table-mounted shield. However, medical staff who approach the patient during fluoroscopy are at risk of being exposed to intense scattered radiation because it is difficult for them to use the shield when approaching the patient.

The medical staff should be instructed to inform the operator before approaching the patient. The operator should interrupt the fluoroscopy when the staff approaches the patient to prevent unnecessary exposure to radiation. Such consideration can significantly reduce the radiation exposure of the staff [5].

On-the-fly Confirmation of Radiation Exposure for Each Procedure: Pocket Digital Dosimeter

The best way to learn how to properly protect oneself from radiation exposure is to get feedback on the actual radiation dose received by the surgeon for each procedure. Even if a textbook state that "radiation exposure can be reduced" depending on the settings of the equipment, there may be cases where there is little or no reduction in radiation exposure, or where there is a theoretical reduction in radiation exposure but only a small practical reduction.

The use of pocket digital dosimeters is useful for measuring the operator's own radiation exposure for each procedure. It is shocking to see on the digital display how many microsieverts of radiation one has been exposed to during each procedure, and this can certainly increase the operator's awareness of radiation protection.

The effective dose is calculated using the following formula [1].

$$HE=0.11Ha+0.89Hb$$

HE: effective dose, Ha: dose equivalent outside lead apron, Hb: dose equivalent inside lead apron.

Breakage of Lead Apron

Accidents involving radiation exposure of doctors and nurses due to damage of lead aprons have been reported. Even if there appears to be no damage from the surface of the lead apron, the shielding inside the apron may be damaged. In general, the service life of protective clothing is said to be about 5 years, but it is necessary to check the protective clothing for damage every few months using fluoroscopy.

Conclusion

It is difficult to dispel the anxiety of young doctors as regards radiation exposure and to get them interested in interventional radiology by simply repeating “catchphrases” such as “We are radiologists, so we take radiation exposure very seriously. Therefore, the level of radiation exposure to the operators in interventional radiology is not harmful to their health.”

All interventional radiologists have to raise awareness of radiation protection.

Do you know how much radiation you are exposed to in one of your “routine procedures” ?

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