Individual Dose Estimation of the Medical Stuff in Interventional Treatment Using TLD Method

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ABSTRACT

Objectives: The aim of this study was to measure the effective radiation dose and its distribution in medical professionals' hands and chest during interventional radiology procedures for diagnosis and treatment and to assess the radiation exposure and occupational hazard in their workplace.

Methods: A total number of 438 medical staff (185 interventional radiologists and surgeons, 152 radiologic technicians, and 101 nurses) at 40 hospitals in China participated in this study. The thermoluminescent dosimeters (TLDs) and ring dosimeters were used to estimate the radiation exposure to the chest and hands of effective dose in medical professionals, respectively, during their interventional radiological procedures.

Results: The measurement results showed that the effective dose to the chest and the hands in the medical professionals varied from 0.93 mSv/a to 52.3 mSv/a and 0.20 mSv/a to 227.5 mSv/a, respectively. There were 2.1% interventional radiological staff whose effective dose exceeded the annual dose limit in the total body (20 mSv/a). Interventional radiologists and surgeons received the highest radiation doses among medical professionals, followed by radiological technicians, and nurses received the lowest radiation doses.

Conclusions: Radiological protection of medical professionals during interventional radiological procedures for diagnosis and the treatment is of concern in China. The use of appropriate shielding facilities, the reduction of exposure time during the interventional radiological procedures, and routine monitoring radiation exposure are recommended.

.INTRODUCTION

Interventional radiological procedures are increasingly used for the diagnosis and the treatment in clinical practice (Jankowski, Chruscielewski, Olszenwski, & Cygan, 2002). They have many advantages such as improving the diagnostic quality of examinations and replacing surgery for the treatment. The interventional procedures are faster and cause less traumatic and less complications following the interventional treatment. Patients can also recover soon from interventional procedures. Enormous health benefits are shown from medical uses of interventional radiological procedures and the risks associated with diagnosis and treatment are relatively low. Therefore, they are widely adopted by medical professionals in China (Liu, et al. 2000; Yu, et al. 2005). Interventional radiological procedures become essential tools for improving human health. Patients in China are willing to accept their health care professionals'

recommendations for receiving interventional radiological procedures. However, interventional radiological procedures have disadvantages in clinical practice. They can lead to very high radiation doses due to exposure in both patients and medical professionals. According to the United Nations Scientific Committee, the effects of radiation from the diagnostic medical applications of radiation account for about 95% of the exposure to radiation from human-made sources and about 12% of total exposure (International Atomic Energy Agency, 2001).

Interventional radiological procedures are associated with radiation exposure which may cause injuries and be harmful for the health of patients and medical professionals if inappropriately protected. For instance, when interventional procedures are performed, health care professionals are close to an X-ray tube. If medical professionals perform interventional procedures for a longer time, the chance of receiving radiation doses increase. It is noted that interventional operators such as radiologists usually receive the highest radiation doses among medical professionals (Stranden, Widmark, Sekse, 2008).

Many studies on the investigation of radiation dose measurement in interventional medical staff have been done in western countries (Goni, et al. 2005; Ketelsen, et al., 2009; Lie, Paulsen, & Wohni, 2008; Niklason, Marx, & Heang-Ping, 1993; Pinto, et al., 2007; Pridgeon, Lues, & Du Plessis,2011). However, not many studies on this aspect have been done in China. In the present study, the investigation of radiation exposure to medical professionals was conducted in China. The purpose of this study was to measure the effective doses and the dose distribution in medical professionals' hand and chest in their interventional radiological procedures for the diagnosis and the treatment and to assess the radiation exposure and occupational hazard in their work settings. The results of this investigation are discussed and the recommendations of radiation protection of medical professionals in interventional radiological procedures are made based on the study

results.

SUBJECTS AND METHODS

Subjects

The present study included 438 medical professionals from 40 hospitals in Shandong Province, China. Out of 438 medical professionals, there were 185 interventional radiologists and surgeons, 152 radiographic technicians, and 101 nurses who participated in interventional radiology in cardiology, liver, and lung. All of the participants received radiation dose measurements.

Methods

The TLD reader made in the United States and thermoluminescent dosimeters (TLDs) made in China were used in this study. The measurement range of X-ray was within 0.1 mSv and 10 mSv. All 438 participants wore a badge dosimeter, out of which 158 participants wore a ring dosimeter. All the radiation doses were measured to estimate the radiation exposure to the chest and hands of medical professionals, respectively. A badge dosimeter included three units which medical professionals wore in front of their chest area. If medical professionals wore aprons, the TLD was placed in the collar on the left. A ring dosimeter was worn on the thumb of medical professionals. All the medical professionals wore TLDs and ring dosimeters for three months. All the measurements were conducted in the Department of Radiological Protection and Safety, Shandong Center for Disease Control and Prevention, Jinan, Shandong, China. The TLDs were mailed to each hospital before conducting the measurements.

RESULTS

Dose and Dose Distribution to the Chest in 438 Medical Professionals

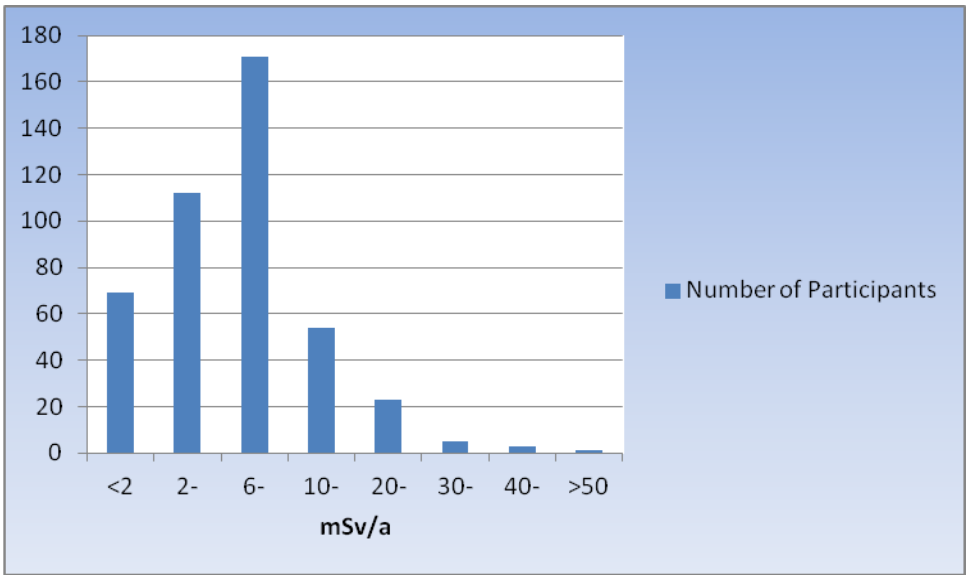
Following the dose measurement for three months, all the participants sent their TLDs and ring dosimeters back to the Department of Radiological Protection and Safety. All the data were collected and analyzed. The results of this study showed that the effective dose to the chest ranked from highest to lowest was as follows: interventional radiologists and surgeons, radiological technicians, and nurses. The interventional radiologists and surgeons received the highest dose (52.3 mSv) to the chest among all the medical professionals who were involved in interventional radiologic procedures. The average annual radiation doses to the chest among medical professionals was 6.8 mSv which was higher than that that of the X-ray radiologists received in Shandong Province (1.8 mSv/a), but lower than that of the international and Chinese standards which limits radiation dose (20 mSv) in this occupation. Three-tenths of the medical professionals (259) exceeded the national annual limits of radiation doses, which accounted for 59% of the participated medical professionals. For detailed information, see Table 1 below.

Table 1. Radiation Doses of the Chest in 438 Medical Professionals (mSv/a)

Occupation	Number of Participants	Annual Exposure Dose	Mean
Interventional Radiologist	185	1.1-52.3	9.4
Radiological Technician	152	0.9-25.6	4.2
Nurse	101	0.9-18.7	3.9
Total	438	0.9-52.3	6.8

The dose distribution to the chest in 438 medical professionals showed that 39% of medical professionals received the average annual dose distribution with the range of 6-10 mSv and 26% of them received the average annual radiation dose at the range of 2-5 mSv. For the detailed results, see Figure 1.

Figure 1. Dose Distribution to the Chest of Medical Professionals (438)



Dose and Dose Distribution to the Hands

Table 2 showed that interventional radiologists and surgeons received the highest radiation doses to their hands during interventional radiological procedures. The doses reached 227.5 mSv. This dose was lower than that of recommended national standards in China (500 mSv). The radiological technicians received half of the radiation dose as did interventional radiologists and surgeons. Nurses received the lowest radiation doses. The radiation dose distribution showed that most of the medical professionals received radiation doses between 6-19 mSv and 20-49 mSv, accounting for 52.5% and 27.8% of the total medical professionals who were exposed to radiation during the interventional radiological procedures.

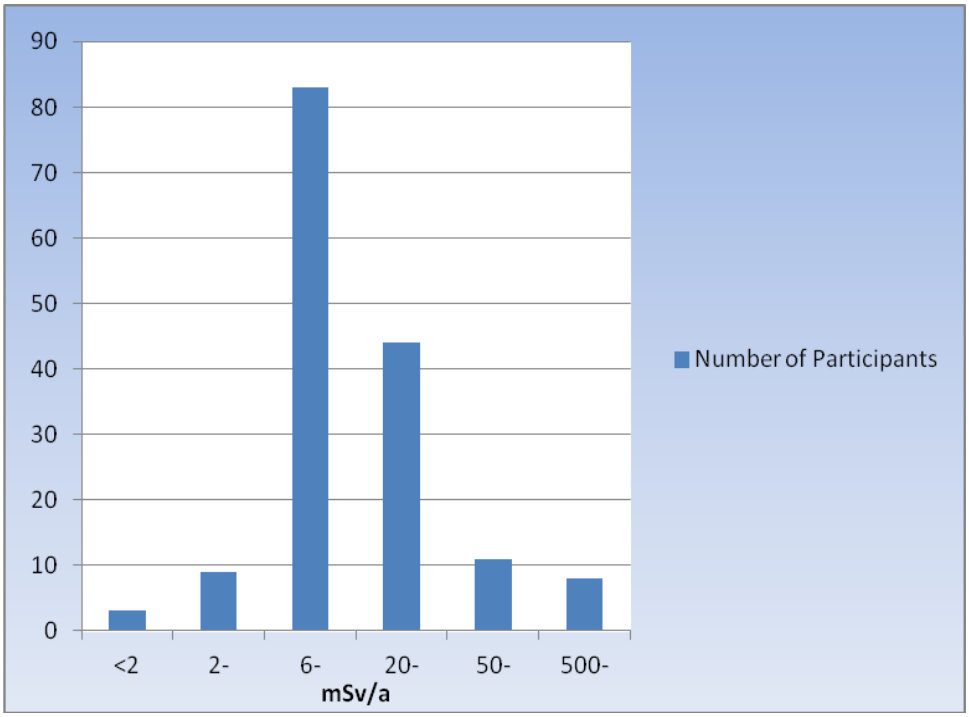
Table 2. Radiation Dose in the hands of 158 Medical Professionals (mSv/a)

Occupation	Number of Participants	Annual Radiation Dose	Mean

Interventional Radiologist	95	1.1-227.5	22.4
Radiological Technician	42	0.8-81.9	10.5
Nurse	21	0.2-16.7	5.9
Total	158	0.2-227.5	15.8

For the detailed information on the dose distribution in the hands of medical professionals, see Figure 2 below.

Figure 2. Dose Distribution to the hands of Medical Professionals (158)



DISCUSSIONS

Interventional radiological procedures are performed by interventional radiologists. The present study results showed that the effective dose and dose distribution to the chest and hands of medical professionals were the highest for the interventional radiologists, then radiological technicians, and finally nurses. This study result is consistent with the results in existing studies (Stranden, Widmark, Sekse, 2008). The reasons for this are that interventional radiologists and

surgeons are close to the X-ray tube and receive exposure to leaking and scattering radiation when performing interventional procedures. It is recommended that interventional radiologists and surgeons should shorten the operation time and avoid placing hands in radiation beams when performing interventional procedures. Exposure to high doses may be associated with inappropriate equipment, lack of skills in operation, and lack of guidelines of radiation protection.

Therefore, radiation protection of interventional medical professionals in China is a challenge issue. It is difficult to deal with it because interventional radiological procedures have to be performed near a patient's bed. At present, many hospitals in China use a simple additive hanging screen or using lead screen close to the bed. It provides some protection, but it is not an ideal protection measure for most circumstances. In addition, exposure to high doses may be related to the posture of interventional radiologists while performing interventional procedures. Another situation is that interventional radiologists and surgeons are exposed to high radiation from different direction when they perform interventional cardio logical procedures. It is suggested that providing shielding facilities should be encouraged to protect medical professionals from radiation exposure in clinical settings.

CONCLUSIONS

Interventional radiological procedures are widely used for medical diagnosis and the treatment in China. However, much attention to radiological protection of medical professionals must be paid when interventional radiological procedures are performed. The use of appropriate shielding facilities, limiting exposure time of the interventional radiological procedures, and monitoring radiation exposure doses routinely are recommended.

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