Analysis for external exposure of nurses engaged in nuclear medicine using a personal dosimeter with a trend function


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Abstract – Occupational exposure of radiation workers, including nurses, is an important issue that should always be considered. However, there are limited reports on external exposure of nurses working in nuclear medicine investigated using a personal dosimeter with a trend function. We investigated the relationship between the personal dose equivalent and behavior of nurses in nuclear medicine using a personal dosimeter with a trend function. It was found that the external exposure of nurses was high when they cleaned hospital rooms where patients who received radiopharmaceutical drugs were admitted. However, none of the nurses surveyed exceeded 3 mSv. Visualization of the contamination in the hospital room showed that the area around the sink and trash can was particularly contaminated. Hence, nurses need to be more careful when cleaning. Although it is unlikely that the nurses surveyed will be affected by external exposure, data in this report is valuable for nurses at medical institutions to consider work hours and personnel strategies.

Keywords: exposure / external / exposure / occupational / nuclear medicine

1 Introduction

It is a well-known fact that radiation workers need to take appropriate measures for external exposure during work (ICRP, 1990, 2012). Recently, the International Atomic Energy Agency (IAEA) recommended, in a technical documentation, that radioprotection for staffs in interventional radiology and nuclear medicine was important (IAEA, 2013). To clarify the factors of external exposure and take the appropriate measures, it is extremely important to investigate and understand the actual conditions of external exposure dose associated with work, such as personal dose equivalent and air dose associated with work time.

There have been several reports from various research facilities and specialized societies regarding the external exposure of healthcare workers in nuclear medicine in Japan (Japan Radioisotope Association, 2008, 2015; Akahane et al., 2014; Matsumoto et al., 2022). In particular, the Japan Radioisotope Association reported that the actual external exposure of medical staffs who worked in nuclear medical was 11.1 μSv to 0.12 mSv in nuclear medicine treatment, approximately 0.08 mSv for preparation and administration, and in nuclear medicine examination, although it depended on the content (Japan Radioisotope Association, 2008, 2015). In nuclear medicine examinations, patients who receive radiopharmaceuticals are a source of radiation. Hence, facility design and actions that consider the reduction of radiation exposure are important. Therefore, “As Low As Reasonably Achievable (ALARA)” is a basic concept of radioprotection. Based on the three principles of achievable/protection, each medical institution strives to reduce radiation exposure on daily basis (ICRP, 1973). However, exposure received by nuclear medicine examination staff is often unavoidable, such as handling radiopharmaceuticals as well as patients, assisting patients, and cleaning hospital rooms.

According to reports of external exposure associated with work in nuclear medicine, it is unlikely that deterministic effects will occur by appropriately controlling the time spent on work. In contrast, there are many reports on nurses’ anxiety regarding radiation exposure. Matsuda et al. (2004) reported that approximately 60% of nurses felt anxious regarding work in the radiology department, regardless of their experience in radiation education. In addition, Watanabe et al. (2015) reported that approximately 35% of nurses in charge of work in nuclear medicine felt anxious.

Based on these views, we investigated the behavioral records and personal dose equivalents of external exposure of nurses in
nuclear medicine using a personal dosimeter with a trend function. The purpose was to provide data that could be used for a factor analysis and radiation education during nursing activities in nuclear medicine by comparing behavior and dose.

2 Materials and methods

2.1 Survey target and their business content

The targets were four female nurses, with more than five years of work experience, who belonged to the authors’ medical institution. A personal dosimeter with a trend function, carried during work, measured the behavior records and personal dose equivalents. The measurement period was one day for each nurse (working hours were approximately eight hours), and was conducted in July 2021. In addition to general nursing work that is not related to the handling of radiopharmaceuticals, cleaning the hospital room where the patient left the room after radioiodine therapy was the main work of the nurses surveyed in this study. Thus, they were not in charge of direct caregiving of patients after radiopharmaceutical administration.

2.2 Personal dose equivalent measurement over time and behavioral recording

A D-Shuttle dosimeter (Chiyoda Technol Co., Ltd.) was used to examine the personal dose equivalent (Čemusová et al., 2017; Naito et al., 2017; Tsubokura et al., 2018; Tsujiguchi et al., 2019). The D-Shuttle was a small and very light Si-diode-based personal gamma-ray dosimeter. It could record personal dose equivalent every hour for a long time, and the measured dose was read via a USB connection to a PC equipped with the dedicated software. Table 1 shows the basic D-shuttle characteristics. In addition, all the D-shuttles used were properly calibrated to satisfy JIS-Z-4312 (Japanese Standards Association, 2013). In addition, a self-describing behavior record sheet was distributed to the target nurses, and their behavior during working hours was recorded at 10-minute intervals.

2.3 Survey of the contamination factors in the hospital room where a patient who received radiopharmaceutical was hospitalized

The GAMMA Catcher (Chiyoda Technol Co., Ltd., Japan), also called Compton Camera (CC), evaluated extensive contamination situation visually by gamma-ray imaging. The CC provided a smaller and lighter camera, more sensitive for bringing and installing in a contamination area. A duty of the nurses’ work in nuclear medicine was to clean the hospital room of a patient who received a radiopharmaceutical drug. To survey the external exposure factors while nurses cleaned the hospital room, we visualized contamination areas by installing the CC. The measuring time was set at 15 minutes and compared before and after cleaning. Table 2 shows the CC characteristics.

2.4 Ethical considerations

Before the study was conducted, we described the purpose of the survey, privacy protection, and anonymity on paper. This study was approved by the Committee of Medical Ethics of Hirosaki University Graduate School of Health Sciences, Hirosaki, Japan (approval number 2017-014).

3 Results

3.1 Nurse behavior records and individual dose equivalents associated with nursing activities

Figure 1 shows the behavior records of the four nurses surveyed and the measurement results of personal dose equivalents. First, regarding the personal dose equivalents of the four nurses during business hours, the lowest nurse was 0.55 µSv and the highest nurse was 2.23 µSv. In Figure 1, the arrow mark indicates the dose during the time the nurse cleaned the hospitalized room, which belonged to a patient who received the radiopharmaceutical drug. When cleaning the hospital room and dumping the garbage, the individual dose equivalents of all nurses were higher than other data.
Fig. 1. Behavioral records and personal dose equivalents of nurses engaged in nuclear medicine. From a to d, the behavior of each nurse surveyed and the result of the dose are compared and displayed. In addition, the arrow mark indicates the time the nurse is cleaning the room and dumping the garbage where the patient was admitted after receiving radionuclides therapy. When the nurses cleaned the hospital room, the patient had already left.
Fig. 1. (Continued)

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Business hours

i. Desk work
ii. Guide the patient to a nuclear medicine laboratory
iii. Garbage disposal in the room where the patient who received radionuclide therapy leaves the room
iv. Cleaning room after a patient receiving radionuclide therapy leaves the room
v. Rest
vi. Nursing work not related to radiation
Furthermore, subjects shown in Figures 1C and 1D had a personal dose equivalent of more than 1 mSv per hour.

3.2 Contamination status of the hospital room where the patient who received the radiopharmaceutical was hospitalized

Since the external exposure of nurses during cleaning of hospital rooms and dumping of garbage increased, the situation of how the contamination situation changed before and after cleaning the hospital rooms was visualized using a CC (Fig. 2). Figure 2A shows the floor plan of the nuclear medicine ward of the medical institution to which the authors belonged and the installation location of the CC. In addition, Figures 2B and 2C show a map of the room where the nurse (shown in Fig. 1C) cleaned and dumped the garbage, and the patient who received radioiodine internal therapy was in for 24 h. The dose of radioiodine was 5.55 GBq. As a result of the visualization, it was confirmed that the contamination was concentrated around the trash can, sink, and toilet.

Fig. 2. Compton camera image when cleaning a hospital room where a patient who received radiopharmaceuticals was hospitalized. (a) The floor plan of the hospital room and the location of the camera; (b) Bedroom contamination status; (c) Bathroom contamination status.
4 Discussion

By combining a personal dosimeter with a trend function and a behavior record, we investigated the actual situation of external exposure of nurses engaged in nuclear medicine work. The follow-up results showed that external exposure during hospital room cleaning and garbage disposal work which patient left was greater than in other nurse’s task. As can be seen from the results of the CC (Fig. 2), this exposure factor is thought to contribute to the contamination of the sink and objects around the bed left by the patient.

In this study, the external exposures of the four nurses during daily work was 3 μSv or less. It should be noted that none of the nurses assisted patients after radiopharmaceutical administration, and it is estimated that they will not be exposed above 1 mSv per year. However, in the past, it was reported that the caregivers of patients who received radioactive iodine received external exposure of up to 250 μSv per week (Denman et al., 2001). In addition, it has been reported that if the patient is able to walk independently, that is, if the patient can keep a distance from the nurse, the weekly exposure dose of the nurse can be suppressed to about 80 μSv per week (Barrington et al., 1996). If nurses assisted patients after radiopharmaceutical administration such as I-131, it is considered that there is a possibility of external exposure far higher than our result. Hence, it should be noted that this survey, which did not reveal any clear external exposure factors other than during cleaning, may be conservative.

From the data of the CC, it was found that the external exposure was higher during garbage disposal, sink, and cleaning work around the toilet compared to other nursing work. Since administered radiopharmaceuticals are excreted outside the body together with sweat and urine, it is unavoidable that contamination accumulates in these places in a hospital room. However, efforts must be made to reduce the external exposure of nurses as much as possible. For example, nurses need to explain to the patient before their work and educate them about the contamination of the sink and objects around the bed.

The personal dose equivalent data shown are shown along with trends and behavioral records and are likely to be helpful in considering nurses’ work plans and time allocations. Although it may vary depending on various conditions, the cleaning work done once or twice a day, even for 200 days of work per year, the external exposure received in the cleaning work would be 1 mSv or less. There is a high possibility that there will be no problem in working as a radiation worker.

However, as shown by ALARA, daily education is important to reduce external exposure reasonably (ICRP, 1973). In Japan, a certification system for specialist nurses and a new curriculum have been started so can work on tasks that involve exposure, such as nuclear medicine, with little anxiety and correct knowledge (Saito, 2014; Yamaguchi et al., 2019). Although the data presented in this study is small, it can be used for radiation safety management education for nurses since it serves as a basis for nurses to understand the relationship between their work and exposure.

5 Conclusion

We showed the relationship between nurses’ behavior and personal dose equivalents. Staffs should be more careful regarding external exposure when cleaning the room which belonged to patients who had radiopharmaceutical administration. This data can be used for nursing education and contribute to fostering a radiation safety culture and reducing anxiety for nurses.

Conflict of interest

None

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Ethical approval

See section 2.4 “Ethical considerations”

Informed consent

None

Author contributions

T. Tsujiguchi was in charge of the nurse’s external dose survey, hospital room contamination survey, and dissertation writing. S. Shukunobe, Y. Sagisaka, and K. Yamanouchi were in charge of the external exposure survey of the nurses. K. Ito was in charge of the hospital room contamination survey. Y. Takahashi was in charge of supervising this research.

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