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NOTE

RADIATION DOSES OF EMPLOYEES OF NUCLEAR MEDICINE DEPARTMENT AFTER IMPLEMENTATION OF MORE RIGOROUS RADIATION PROTECTION METHODS

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The appropriate radiation protection measures applied in departments of nuclear medicine should lead to a reduction in doses received by the employees. During 1991–2007, at the Department of Nuclear Medicine of Pomeranian Medical University (Szczecin, Poland), nurses received on average two-times higher (4.6 mSv) annual doses to the whole body than those received by radiopharmacy technicians. The purpose of this work was to examine whether implementation of changes in the radiation protection protocol will considerably influence the reduction in whole-body doses received by the staff that are the most exposed. A reduction in nurses' exposure by ∼63 % took place in 2008–11, whereas the exposure of radiopharmacy technicians grew by no more than 22 % in comparison with that in the period 1991–2007. Proper reorganisation of the work in departments of nuclear medicine can considerably affect dose reduction and bring about equal distribution of the exposure.

INTRODUCTION

Because they work with open radioactive sources, employees of departments of nuclear medicine are potentially exposed to higher radiation doses compared with employees working in other departments where the ionising radiation is used for medical purposes[(1–3)]. The appropriate radiation protection measures applied in departments of nuclear medicine should, therefore, reduce the doses absorbed by their employees. The analysis of doses received by employees at the Department of Nuclear Medicine of Pomeranian Medical University in Szczecin (Poland)[(4)] during 1991–2007 showed that the average doses received by nurses were two times higher than those by radiopharmacy technicians, whereas the overall exposure of workers was higher than that reported in the UNSCEAR world report of 2000[(3)]. The department head and radiation safety officer have since implemented changes in the workplace for the benefit of the employees who are the most exposed. The aim of this study was to examine whether the implemented changes affected the level of absorbed doses received by the employees. It describes the analysis of doses absorbed by employees during 2008–11 and compares the exposure of individual occupational groups with those monitored in earlier years.

MATERIALS AND METHODS

The analysis of department of nuclear medicine employees' radiation exposure in the period between 1991 and 2007[(4)] has led the department head and radiation safety officer to improve the level of radiation protection, especially for nurses. The following were the most significant innovations:

- A reduction in nurses' participation in patient examinations.
- Before 2008, nurses routinely performed patient imaging examinations in addition to the preparation and administration of radiopharmaceuticals. From 2008, radiopharmacy technicians performed imaging examinations and nurses occasionally performed patient studies.
- The purchase of new tungsten syringe shields for the injection of radiopharmaceuticals.
- Difficult-to-use lead syringe shields were replaced by lighter, tungsten shields fitted with a spring loaded securing pin to hold the syringe in position.
- More frequent practical training on radiation protection.
- Nurses and radiopharmacy technicians were systematically trained for all manual hot-laboratory

activities concerned with preparing and dispensing radiopharmaceuticals. Water and models were used in place of radioactive materials for this training. In order to promote quick and accurate use of radioactive materials and equipment, proper handling of vials with tweezers and forceps was practised repeatedly as was fast and precise handling of shielded syringes and ampoules. Radioactive spill and decontamination procedures were rehearsed by the workers also.

Overall, 412 quarterly effective whole-body doses monitored with personal badges with Kodak film during the period 2008–11 were analysed. A personal dose equivalent at a depth of 10 mm, Hp (10), for dosemeters worn on the chest was used as an estimator of the effective dose. As in the period 1991–2007, the dosimetric system was operated and calibrated at the Central Laboratory for Radiological Protection (CLRP) in Warsaw during 2008–11. The film badge system had a method detection limit of 0.1 mSv. The uncertainty designation of the individual dose equivalent Hp (10) was 22 %.

Nurses, radiopharmacy technicians and technicians were regularly monitored for hand exposure, using ring thermoluminescent (TL) dosemeters from the last quarter of 2008. Dosemeters were worn on the middle finger of the dominant hand. TL rings were sent quarterly to the Laboratory of Individual and Environmental Dosimetry, Institute of Nuclear Physics, Polish Academy of Science in Krakow, for the measurement of personal equivalent dose values: Hp (0.07), which is an assessment of the dose equivalent to the skin. The range for the measurement method was 0.1 mSv–1 Sv. In total, 151 quarterly extremity doses during 2009–11 were analysed.

During the examined period, a wide spectrum of diagnostic and therapeutic procedures were carried out at the department, mainly examinations of the thyroid gland, kidneys, heart, skeleton, limphoscyntygraphy and I131 iodine therapy for thyroid gland diseases.

RESULTS

The number of therapeutic and diagnostic procedures performed during 2008–11 ranged from 2514 to 6660 per year (5285 procedures/year on average). In the analysed period, the number of employees with controlled radiation exposure ranged from 27 to 28. Compared with the period 1996–2007[4], the average number of executed procedures increased by ~28 %. Each employee was assigned to an occupational category: nurse, physician, technician, radiopharmacy technician, administration staff and ancillary staff. The nurses' tasks were mainly to prepare radiopharmaceuticals for patients and give injections, whereas radiopharmacy technicians prepared radiopharmaceuticals and performed imaging examinations of patients. Both radiopharmacy technicians and nurses worked in a hot laboratory in a rotating-shift system. Doctors occasionally gave radiopharmaceuticals to patients.

Figure 1 illustrates the comparison of the distribution of annual effective whole-body doses for 1991–2007 and 2008–11. In the years 2008–11, a total number of lower doses increased: by 9 % for doses <0.4 mSv and by 6 % for doses in the range 0.4–1 mSv. Therefore, the number of registered doses >1 mSv decreased, altogether for ~15 %.

Table 1 shows the average dose ranges and the average doses of consecutive occupational groups in the investigated years. The highest effective doses were recorded for radiopharmacy technicians and nurses, who had maximum annual doses of 17.5 and 5.8

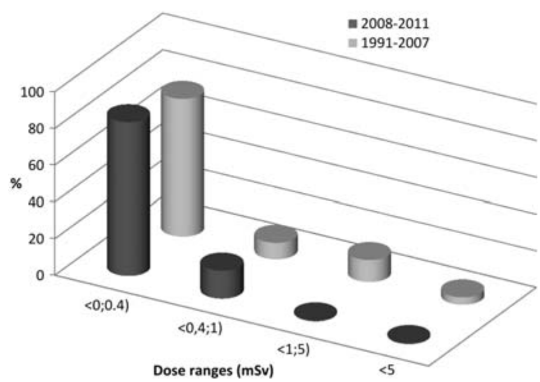

Figure 1. Comparison of the distribution of annual individual doses in the periods 1991–2007 and 2008–11.

Table 1. Average annual effective and extremity doses of employees for consecutive occupational groups.

Occupational group	Average annual effective doses (mSv) during 2008–11		Average annual extremity doses (mSv) during 2009–11	
	Range	Dose	Range	Dose
Nurses	0.6–5.8	1.7	13.2–86.4	39.7
Technicians	0.0–1.3	0.4	0.5–9.2	2.7
Radiopharmacy technicians	1.2–17.5	2.8[a], 1.8[b]	3.2–41.2	21.9
Physicians	0.1–0.9	0.5		
Administration staff	0.0–0.5	0.1		
Ancillary staff	0.0–0.3	0.1		

[a]Dose calculated based on all doses recorded.
[b]Dose calculated by omitting the extreme 16.6 mSv individual dose recorded.

mSv, respectively. The mean dose achieved by radiopharmacy technicians, 2.8 mSv, was significantly increased because of an extreme individual quarterly dose of 16.6 mSv. In the third quarter of 2008, a radiopharmacy technician who had been working in the department of nuclear medicine for 20 y was contaminated with Tc99m by a personal dosimetric cassette while performing routine activities in the hot laboratory. The subsequent readings of doses for this employee were similar to the recorded level for other radiopharmacy technicians performing analogous professional activities. The total sum of registered doses for this employee in 2008 amounted to 17.5 mSv, which was lower than the annual dose limit connected with occupational exposure (20 mSv). For the purposes of this study, the average doses for radiopharmacy technicians were calculated with and without taking into account this extreme individual dose and were measured as 2.8 and 1.8 mSv, respectively. The average dose for physicians during the period 2008–11 was ~0.5 mSv, whereas administrative staff and ancillary staff received doses at the sensitivity limit of the dosimetry method.

Table 1 also contains information on doses to the hands of monitored workers. All extremity doses were relatively low and the main reason for this was the rotating system of preparing radiopharmaceuticals in shifts, which brought about a low number of working hours in the hot laboratory for each nurse and radiopharmacy technician. The results were also low because they were obtained from dosemeters worn on the middle finger of the dominant hand, which cannot show, because of the position of the ring detector on the finger, actual doses absorbed by the most exposed areas of the hand, i.e. the fingertips and the nails, where real skin doses can be up to five times higher than that indicated in Table 1[5,6]. However, when taking into account a correction factor of 5 for the position of the ring dosemeter, the results show that monitored employees did not exceed annual extremity dose limits. Extremity doses to nurses and to radiopharmacy technicians were comparable.

Figure 2 illustrates the differences between the average effective doses calculated for the period 1991–2007 and 2008–11 for individual occupational groups. The average dose for nurses, 1.7 mSv, decreased by 63% from the earlier analysed period of 1991–2007. The exposure of radiopharmacy technicians increased by 22%. Technicians, physicians, administrative staff and ancillary staff received average annual whole-body doses below 1 mSv.

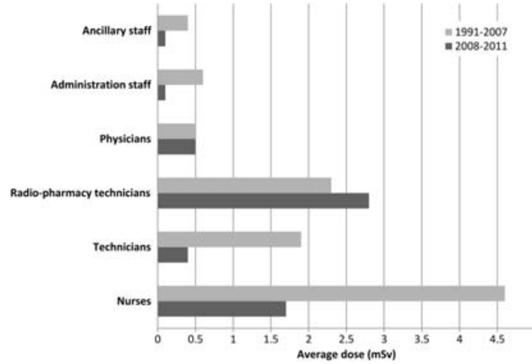

Figure 2. Comparison of average doses received by employees of individual occupational groups in the periods 1996–2007 and 2008–11.

DISCUSSION

Reorganisation of the work, frequent trainings, especially for exposed employees, and the application of more comfortable syringe shields reduced the radiation doses for nurses. These strategies are in concordance with the recommendations of the IAEA[7]. The average dose for radiopharmacy technicians calculated by omitting the extreme individual dose recorded was 1.8 mSv, which is equivalent to the average dose received by nurses. Moreover, during 2008–11, the number of doses >1 mSv was distinctly reduced in comparison with the period 1991–2007. In addition, the number of performed procedures increased in 2008–11, whereas the number of employees was practically unchanged. Extremity doses to the most exposed workers did not exceed the annual limit in the period 2009–11.

Currently, few papers describe the analysis of annual effective doses received by individual occupational groups at conventional departments of nuclear medicine. In a paper on radiation exposure of medical employees in Lithuania[8], the annual average dose received by technicians (who perform the duties of radiopharmacy technicians) was 2.12 mSv, which is very similar to the doses measured at the studied department. In a Portuguese study[9], the calculated doses were a little higher, amounting to 3.2 mSv for nurses and to 3.3 mSv for technicians. We agree with the authors[10] that the exposure level is dependent on the responsibilities of the employees. The technologists in the described Iranian department of nuclear medicine received average annual doses of ~8.8 mSv; however, the scope of their activities included giving injections to patients. In a Brazilian department of nuclear medicine in 2000–03, the average annual doses received by biologists and nurses amounted to 9.2 and 6.7 mSv, respectively[11]. Because of the relatively large differences between the doses received by employees in individual departments, a reasonable solution could be to set dose limits for employees categorised under the same occupational group[12]. Based on the analysis of the results for the 4 y investigated, individual monitoring in the medical sector has determined dose limits of 2.2 mSv for technicians and 1.7

mSv for doctors working in the departments of nuclear medicine in Greece[13]. Exceeding these set limits should oblige the heads of hospitals to undertake measures to reduce the radiation exposure of their employees.

CONCLUSIONS

(1) Reorganisation of the work and a higher level of radiation protection lowered the exposure of nuclear medicine department nurses to ionising radiation while maintaining a safe level of exposure for all occupational groups.

(2) The high doses received by employees should be analysed and explained individually. Incidents of contamination with radioisotopes can take place during work with open radiation sources even among employees with a long work experience.

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