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A N I N T E R N A T I O N A L J O U R N A L

Radiation Exposure in Nuclear Medicine: Real-Time Measurement

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ABSTRACT

French regulations have introduced the use of electronic dosimeters for personal monitoring of workers. In order to evaluate the exposure from diagnostic procedures to nuclear medicine staff, individual whole-body doses were measured daily with electronic (digital) personal dosimeters during 20 consecutive weeks and correlated with the work load of each day. Personal doses remained always below 20 µSv/d under normal working conditions. Radiation exposure levels were highest to tech staff, nurses and stretcher-bearers. The extrapolated annual cumulative doses for all staff remained less than 10 % of the maximum legal limit for exposed workers (2 mSv/yr). Electronic dosimeters are not technically justified for routine survey of staff. The high sensitivity and immediate reading of electronic semiconductor dosimeters may become very useful for exposure control under risky working conditions. It may become an important help for optimising radiation protection.

Key words: Dosimetry, exposure, electronic dosimeters, personal monitoring, equivalent dose

INTRODUCTION

The 96/29/Euratom Directive has introduced new constraints for individual dosimetry of workers (ICRP, 1991). Some European countries have already introduced the use of electronic dosimeters to monitor external radiation of exposed staff. French regulations for optimisation of radiation protection of workers have introduced a real-time dosimetry that is complementary to passive personal monitoring (Decree n°. 98, 1998; Order of Mar 23, 1999). Every worker classified as "radiation exposed" and working in a controlled area must use an electronic dosimeter for their personal monitoring. The radiation protection of workers has been satisfactory before the advent of real-time dosimetry. The evaluation by dosifilms has been shown that nobody working in nuclear medicine (NM) received an individual dose above the maximum legal limit (OPRI, 2001; Aubert et al., 1997). Only approximately 1 % of workers have a radiation exposure equivalent to 10 % of the maximum limit. But, the electronic personal dosimeters (EPD) are very attractive for personal monitoring because the semiconductor detection is up to two hundred times more sensitive than films. EPD provide real-time dose and rate dose. EPD are equipped with an audible alarm. This alarm may be useful in situations of radiological incident. The tests of EPD radiological performances have shown an acceptable reproducibility, linearity and energy response for the radionuclides used in nuclear medicine, allowing a good accuracy of the measurements

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(Texier et al., 2001; Ortega et al, 2001; Himing & Yuen, 1995). The goal of this study was to evaluate the exposure from diagnostic procedures to NM staff by electronic personal dosimeters, in order to improve the working conditions allowing to optimise the radiation protection.

MATERIALS AND METHODS

Real-time dosimetry evaluations were performed in the nuclear medicine department. Individual whole-body doses were measured daily with electronic personal dosimeters (EPD Mk2 - Siemens). First, electronic personal monitoring was performed on everybody working full time in a controlled area. One pharmacist, two nurses, five tech staff and two lab technicians were then monitored during 20 consecutive weeks. Second, the equivalent doses were evaluated to other professionals working not exclusively in controlled area but who are sometimes around patients undergoing scintigraphy. Three physicians, two stretcher-bearers, one receptionist and one administrator were controlled during a period of two weeks. The individual radiation doses of the NM staff were correlated with the work load of each day.

RESULTS AND DISCUSSION

The activities in our NM department consist essentially of diagnostic scintigraphy. No high therapeutic doses are employed. The average daily whole-body doses and the maximum individual radiation doses correlated with the highest radiation exposure task are shown on the tables below to the person most exposed within each professional category.

Table 1 - Real-time daily average and maximal whole-body doses, measured during a period of 20 weeks, to the most exposed staff within each professional category correlated with the highest radiation exposure task

Category	Whole-body average dose (μSv/d)	Whole-body maximal dose (μSv/d)	Task
Tech Staff	9.6	20.0	Bone scint
Nurse	6.2	19.3	Bone scint
Lab Tech	2.2	11.3	Iode131
Pharmacist	0.9	1.5	Q.C.

Table 2 - Real-time daily average and maximal whole-body doses, measured during a period of 2 weeks, to the most exposed staff within each professional category correlated with the highest radiation exposure task

Category	Whole-body average dose (μSv/d)	Whole-body maximal dose (μSv/d)	Task
Physician	1.4	2.6	Bone scint
Cardio doc	0.3	0.4	Ejection fraction
Stretcher-bearer	6.7	18.3	Patient contact
Receptionist	0.7	0.9	Patient contact
Administrator	0.5	0.7	Patient contact

We found that radiation exposure levels were highest to tech staff, nurses and stretcher-bearers. The personal doses observed for all workers were below 20 μSv/d under normal working conditions. The highest average whole-body dose was 9.6 μSv in one day. We have also observed that bone scintigraphy seems to be the most critically exposed task. Assuming 220 working days/yr, the highest extrapolated annual cumulative dose was 1.9 mSv/yr to tech staff. The average exposure level to tech staff varied from 1.0 to 1.7 mSv/yr; and to nurses varied from 1.0 to 1.2 mSv/yr.

Radiation exposure levels were significantly lower to lab technicians and a pharmacist who performed exclusively in vitro assays (Figure 1). The exposure of stretcher-bearers was much higher than that of doctors or staff working in offices, administration and reception (Figure 2). Their exposure level was similar to that of tech staff and nurses (from 0.9 to 1.5 mSv/yr) because they have to spend a long time with patients undergoing scintigraphy.

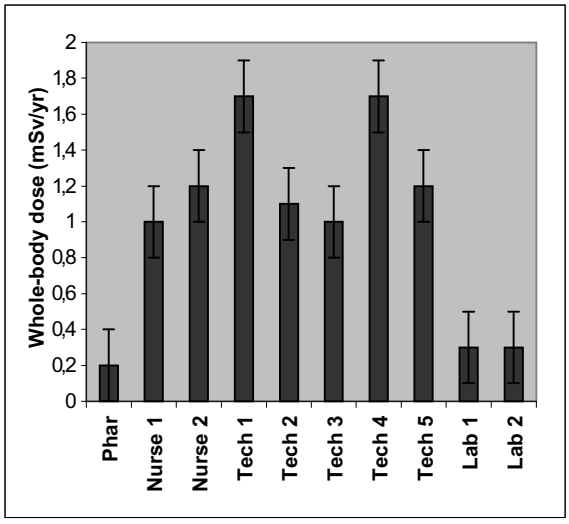

Figure 1 - Extrapolated annual cumulative dose of one pharmacist, two nurses, five tech staff and two lab technicians of the Nuclear Medicine department

The doses of all staff working in our department under normal conditions was far below the legal limit (20 mSv/yr). It means that they can be classified in a lower radiation exposure category and consequently it is not necessary to have electronic or real-time dosimetry for them. The real-time system is very expensive, but it can be used immediately after measurements, as opposed to dosifilms. The time spent on statistical exploitation is very long and it is necessary to undertake staff training and hospital network integration. On the other hand, real-time dosimetry can be very useful in improving working conditions by identifying risk situations, and for evaluation of particular situations. For example, when anyone may have to spend a long time with a patient who has received a treatment or in the case of an incident with potential irradiation. In our opinion, electronic dosimeters are not technically justified for routine survey of whole-body doses of staff in our department. In nuclear medicine applications, the hands are the most exposed part of the body, and therefore, in the future, the hands should be submitted to electronic monitoring as soon as the corresponding devices are developed.

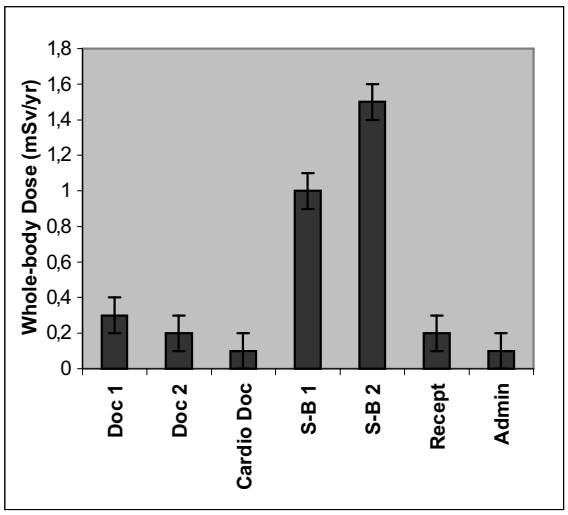

Figure 2 - Extrapolated annual cumulative dose of two nuclear medicine physicians (Doc), one cardiologist (Cardio Doc), two stretcher-bearers (S-B), one receptionist (Recept) and one administrator (Admin) of the Nuclear Medicine department

RESUMO

A legislação francesa introduziu o uso de dosímetros eletrônicos para monitoração da exposição do trabalhador. Afim de avaliar a exposição do trabalhador proveniente de exames diagnósticos em medicina nuclear, doses individuais do corpo inteiro foram medidas diariamente com dosímetros eletrônicos (digitais) durante 20 semanas consecutivas e correlatas com as atividades de trabalho de cada dia. As doses foram sempre inferiores à 20 µSv por dia em condições normais de trabalho. Os níveis de exposição de radiação mais elevados foram para os enfermeiros, manipuladores e maqueiros. A extrapolação da dose anual para todos os trabalhadores foi menos que 10 % do limite máximo legal para os trabalhadores expostos (2 mSv/ano). Dosímetros eletrônicos não são tecnicamente justificados para a o controle de rotina da exposição dos trabalhadores, mas a alta sensibilidade e a leitura imediata desses dosímetros podem vir a serem muito úteis para o

controle da exposição em condições de trabalhos criticas. Neste ultimo caso, dosímetros eletrônicos podem representar uma ajuda para a otimização da radioproteção.

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