External radiation dose to ward staff from nuclear medicine patients: An extended real time survey

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Abstract. Ward staff in hospitals are often exposed to ionizing radiation from in-patients who have been injected by radiopharmaceuticals. Published data concerning this issue are mostly based on dose-rate measurements and occupancy factors. For this reason the Radiation Protection Office of the University Hospital of Brussel (UZ Brussel) started a study in order to assess the workaday reality concerning the external radiation dose. During 6 months 70 ward staff members were monitored during their daily tasks by means of thermoluminescent detectors (TLDs) that were attached on their hospital identification card. Additional TLDs were placed in various hospital and domestic locations to register different background levels. TLDs were calibrated in a secondary calibration laboratory. Calibrations were performed with the 250 keV ISO narrow X-ray spectrum. Simultaneously the activity and type of radiopharmaceutical entering the wards as well as individual workload of the staff members was recorded. Specific guidelines prevented loss of data and registration of exposures that where not job related.

Despite the relatively high amount of activity entering in some wards, only 4 staff members received a dose that exceeds the significance level above the average background.

Although the exposure to external radiation is very limited, additional exposures from radioactive contaminations can occur. The latter exposure pathway to ward staff could not be quantified during this study but can easily be avoided if the need for hygienic measures is emphasised.

The results of this survey can help to encourage risk communication regarding the radiation exposure from nuclear medicine patients, which is presently nonexistent in many hospitals. This communication is extremely important to temper total indifference as well as radiophobia.

KEYWORDS: nuclear medicine, ward staff, radiation protection

1. Introduction

During nuclear medicine procedures a patient is injected by radiopharmaceuticals and consequently acts as a radiation source during and after these procedures. The radiation dose to nuclear medicine workers is described in many publications, but the exposure to individuals also happens outside the nuclear medicine department. Among these critical groups we can consider individuals inside the hospital and outside the hospital such as ward staff, porters, ultrasonographers, family members and many others. [1]. A considerable number of patients, especially high dependency patients, are not discharged from hospital but return to the ward and in this way ward staff members can be the most exposed individuals outside the nuclear medicine department. Previous publications indicate that the exposure to ward staff mostly stays under the dose limit for the public but [2] can become problematic when nursing staff has to take care for high dependency patients [1].

These studies [3-4] use different methods to estimate the dose to medical staff each having the disadvantage that the recorded dose is specific to the condition under which it was measured. To be able to record the actual exposure to the ward staff we introduced a more direct method over a long term period.
2. Material and Methods

Physical condition of the in-patients are very variable (anatomy, incontinence, stoma, …) which causes problems to determine the correct effective half-live by measuring dose rates. Results obtained by dose rate measurements are often not suitable to assess the realistic exposure to critical groups, covering all different nursing tasks, patient condition and working situations. Real time measurements could be performed by providing ward staff members with a TLD during a six months period. This long period intercepts the background fluctuation and covers most possible exposure pathways. Since the use of ordinary TLD-badges asks for discipline and can influence the personnel’s behavior towards nuclear medicine patient, the TLDs where discreetly integrated to the personal identification badge. The TLD’s attached on this badge were calibrated to Hp(10) using the 250 keV ISO narrow X-ray spectrum.

From a resident study we could selected 4 departments where numerous nuclear medicine patients are hospitalized: cardiology, endocrinology, neurology and geriatric ward. 70 ward staff members with different tasks (nurses, logistic workers and physiotherapists) where wearing a TLD on their badge during 6 months. During the same period TLDs where also placed in each ward office. Since the nursing staff members spend only an average of 8 hours in the ward, additional TLDs were placed into cars, offices and private homes to evaluate background influence (shielding, construction materials). A number of worker- and patient-related parameters can influence the order of magnitude of exposures. Worker parameters such as full time, part time, day-, night or weekend shifts were noted. The number of patients and the type of nuclear medicine procedure represent the most important patient related parameters and were carefully recorded for each ward. The level of dependency, which can be very important for possible exposures, was not taken into account since this level can vary for a single patient during the hospitalisation period. Each staff member received guidelines to prevent loss of data (TLD warming up) and the detection of radiation not in relation to daily tasks (medical exposure).

3. Results

During the six months period 1649 patients entered the different wards of UZ Brussel. In the selected departments, cardiology, endocrinology, neurology and geriatric ward, respectively 257, 203, 122 and 79 (Figure 1) patients were hospitalised.

Figure 1: Distribution of nuclear medicine patients over the different wards in UZ Brussel
The fact that $^{99m}$Tc is the most used radionuclide in nuclear medicine is confirmed by multiplying the different nuclear medicine procedures with the corresponding reference activities [5]. As a result a total activity of respectively 162, 122, 82 and 50 GBq could theoretically enter the cardiology, endocrinology, neurology and geriatric ward. (Figure 2). The real activity that enters the wards is in fact very difficult to determine due to the combination of different effective half-lives of the radiopharmaceuticals and the moment of return of the patient from the nuclear medicine department.

**Figure 2:** Maximum amount of activity that could enter the selected wards during the 6 months period

![Figure 2: Maximum amount of activity that could enter the selected wards during the 6 months period](image)

**Figure 3:** Dose distribution of background measurements and staff monitoring

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The total measurement period of the TLD’s was 231 days since the time needed for providing, collecting and the transfer for read-out covers more than the 6 months period. In total 89 TLDs were used for background level detection, 44 TLDs were put aside in the 4 different ward offices, 45 TLDs were spread over different domestic locations. The background results show a normal distribution with an average value 589µSv over the measurement period of 231 days and a 95% confidence level of 728µSv (Figure 3).

Taking into account the background radiation, only 4 staff members received a dose slightly higher than the confidence level of the background fluctuation. The highest dose of 186µSv above the average background can be due to the fact that this person acted as fellow traveller of a family member during several hours after an ambulant radionuclide therapy with $^{131}$I.

4. Discussion and conclusion

This study where 70 ward staff members were monitored during a 6 month period, confirmed that the external radiation dose to ward staff from diagnostic nuclear medicine procedure is rather low. For only 4 personnel members out of 70 the dose was slightly significant higher than the background level. However, it should be stated that during this 6 months survey not a single low-dose therapeutic procedure was recorded where the patient entered one of the 4 wards. Moreover, besides the external exposure there is also a risk for contamination which is not monitored during this study and which is almost impossible to carry out in practice. But, in relation to the low level of external exposure and due to the general hygienic hospital rules, it is possible to reduce the contamination risk to a minimum.

Previous studies are mostly based on dose rate measurements and mathematical models [3-6] and find that the average dose to members of the ward staff is 24 µSv for a single 8h shift [6]. Taking care for high-dependency patients or partially helpless patients a dose of 112 µSv [3] a day can be reached. Gomez stated that working in a cardiology ward or internal medicine section can lead to an annual dose of 518 µSv [7].

This study uses an integral dose method and indicates that, due to background fluctuations and the long-period survey, very few significant exposures can be found even in cases where 500 outpatients per year are hospitalised in a single ward.

The introduction of strict radiation protection procedures is consequently not appropriate for diagnostic procedures since they may result in unnecessary restrictions on clinical practice. Nevertheless it is important to inform medical staff correctly to prevent total indifference to radiation protection on the one side, to radiophobia on the other side.

REFERENCES