Estimation of radiation dose received by the radiation worker during F-18 FDG injection process

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ABSTRACT

Background: The radiation dosimetric literature concerning the medical and non-medical personnel working in nuclear medicine departments are limited, particularly radiation doses received by radiation worker in nuclear medicine department during positron emission tomography (PET) radiopharmaceutical injection process. This is of interest and concern for the personnel. Aim: To measure the radiation dose received by the staff involved in injection process of Fluorine-18 Fluorodeoxyglucose (FDG). Materials and Methods: The effective whole body doses to the radiation workers involved in injections of 1511 patients over a period of 10 weeks were evaluated using pocket dosimeter. Each patient was injected with 5 MBq/kg of F-18 FDG. The F18-FDG injection protocol followed in our department is as follows. The technologist dispenses the dose to be injected and records the pre-injection activity. The nursing staff members then secure an intravenous catheter. The nuclear medicine physicians/residents inject the dose on a rotation basis in accordance with ALARA principle. After the injection of the tracer, the nursing staff members flush the intravenous catheter. The person who injected the tracer then measures the post-injection residual dose in the syringe. Results: The mean effective whole body doses per injection for the staff were the following: Nurses received 1.44±0.22 μSv/injection (3.71±0.48 nSv/MBq), for doctors the dose values were 2.44±0.25 μSv/injection (6.29±0.49 nSv/MBq) and for technologists the doses were 0.61±0.10 μSv/injection (1.58±0.21 nSv/MBq). It was seen that the mean effective whole body dose per injection of our positron emission tomography/computed tomography (PET/CT) staff who were involved in the F18-FDG injection process was maximum for doctors (54.34% differential doses), followed by nurses (32.02% differential doses) and technologist (13.64% differential doses). Conclusion: This study confirms that low levels of radiation dose are received by staff during F18-FDG injection and these values can be used as a reference to allay any anxiety in the radiation workers.

Keywords: Positron emission tomography/computed tomography, pocket dosimeter, radiation dose

INTRODUCTION

Positron emission tomography integrated with computed tomography (PET/CT) is emerging as an important imaging modality in management of patients, especially in oncology. The unique ability of the system to provide both functional and morphological information at cellular level has made it the modality of choice in most of the oncological setups. PET radio-pharmaceuticals are positron emitters which emit 511 keV annihilation photons. They are detected simultaneously by coincidence systems of the PET system on antiparallel detectors. Annihilation photon being high energy radiation poses additional radiation safety problems in the department. Special attention is required when dealing with radiation protection aspects in a PET/CT facility in order to minimize the absorbed dose for workers. Since major portion of radiation exposure is involved in injection process concerning the medical personnel working in PET/CT departments, we measured the radiation dose to the staff involved in injection process in the PET/CT department (Bioimaging Unit), Tata Memorial Hospital. In our department, on an average, 23–28 (F18-FDG) PET/CT studies are performed every day and for 5 days a week.

MATERIALS AND METHODS

Injection procedure
The injection of F18-FDG is carried out as a group task/collective responsibility of the doctors, nurses and technologist, so as to minimize the radiation exposure to the staff.

The technologist dispenses the dose to be injected and records
the pre-injection activity. Then, the nursing staff members secure an intravenous catheter. The nuclear medicine physicians/residents inject the dose on a rotation basis in accordance with ALARA principle. After the injection of the tracer, the nursing staff members flush the intravenous catheter. The person who injected the tracer then measures the post-injection residual dose in the syringe.

To estimate the equivalent dose, all staff members (nurses, doctors and technologists) used pocket dosimeter at the time of injection in addition to their routine TLD badges.

**Dose measurements**

Electronic pocket dosimeters (EPD; DIGIDOSE, BARC, Mumbai, India) were used for this study. The measurement range of the detector was from 1 to 99,999 μSv. These dosimeters have silicon semiconductor detectors with an accuracy of ±10% and an energy response accuracy of ±25% between 40 keV and 1.2 MeV. The constancy of the dosimeters was checked against a 137Cs source before use. During the 10-week study period, EPDs were worn by each staff member. The dosimeters were worn exclusively at times when the staffs were performing the F-18 FDG dispensing/injections. The chest dose received by the staff was read directly from the dosimeters and recorded at the end of each injection. The dosimeters were reset prior to the next injection. The total activity administered and the numbers of injection performed by the staffs were recorded.

**RESULTS**

The mean effective whole body doses to the doctors, nurses and technologists involved in the injection process were expressed in terms of a) per F-18 FDG injection procedure, b) per MBq and c) differential doses, which are tabulated in Tables 1 and 2.

**DISCUSSION**

The use of positron emitters will continue to increase in nuclear medicine practice due to increasing popularity and several advantages of PET/CT imaging.\(^{[2,4]}\) It is imperative to continually monitor the dose received by the staff to check if it is within the prescribed annual dose limits. It reassures the worker of the low level of radiation associated with nuclear medicine procedures and helps in improving the work practice. The critical groups that get exposure from radioactive injections in our PET/CT facility are the doctors, nurses and technologists performing the injection. In this study, we computed/measured the dose to the doctors, nurses and technologists per injection procedure. There are few studies available in the literature comparing the dose received by the staff in conventional nuclear medicine and PET imaging.\(^{[5,6]}\)

The mean whole body dose per procedure to the staff in conventional nuclear medicine has been reported to be much lower than that in PET facility.\(^{[5]}\) This is due to higher exposure rate constant for positron emitting radiopharmaceuticals. We measured the whole body effective doses of the staff working in our PET/CT facility during the injection procedure. In our study, the maximum mean whole body dose was received by the physicians administering the activity. It was twice the value received by the nursing staff. It was least for the technologist. It has been found that these doses are within safe limits as prescribed by the national competent authority.

**Limitations**

The effective dose for the radiation worker involved in the F18-FDG injection procedure may vary with the protocol used in the respective departments.

**CONCLUSION**

This study confirms that low levels of radiation dose are received by staff during F18-FDG injection and these levels are within safe limits as prescribed by the national competent authority. These values can be used as a reference to allay any anxiety in the radiation workers. Good work practices like bringing the injection table near to the L-bench and use of proper shielding devices may further reduce the exposure to the radiation worker during injection.

| Table 1: Mean effective dose to staff during FDG injection |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| A                      | Technologist 1               | Technologist 2               | Technologist 3               | Technologist 4               | Technologist 5               |
| Dose (nSv/MBq) | 1.45±0.37               | 1.55±0.36               | 1.53±0.43               | 1.44±0.41               | 1.74±0.45               |
| Dose (µSv/Injection) | 0.51±0.14               | 0.57±0.13               | 0.52±0.13               | 0.53±0.15               | 0.59±0.16               |
| B                      | Doctor 1               | Doctor 2               | Doctor 3               | Doctor 4               | Doctor 5               |
| Dose (nSv/MBq) | 5.83±1.08               | 6.26±1.14               | 6.28±1.04               | 5.96±1.01               | 6.66±1.11               |
| Dose (µSv/Injection) | 2.02±0.37               | 2.30±0.31               | 2.15±0.31               | 2.18±0.34               | 1.45±0.37               |
| C                      | Nurse 1               | Nurse 2               | Nurse 3               | Nurse 4               | Nurse 5               |
| Dose (nSv/MBq) | 4.16±0.99               | 4.19±0.91               | 3.98±1.01               | 3.28±1.35               | 3.80±0.89               |
| Dose (µSv/Injection) | 1.44±0.34               | 1.55±0.34               | 1.38±0.39               | 1.19±0.41               | 1.28±0.27               |

| Table 2: Radiation exposure to different category of staff |
|------------------|------------------|------------------|------------------|
|                  | Doctors          | Technologist     | Nurses           |
| Avg. dose received per injection (µSv) | 2.44±0.25               | 0.61±0.10               | 1.44±0.22               |
| Avg. dose received (nSv/MBq) | 6.29±0.49               | 1.58±0.21               | 3.71±0.48               |
| Fractional dose received | 54.34%               | 13.64%               | 32.02%               |
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