



Radiation doses Received by Nuclear Medicine Workers with 18F-FDG PET/CT

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Abstract

In addition to the physical properties of positron emissions, the growing use of hybrid systems like PET/CT for diagnostic purposes poses a significant health danger to radiation workers. Using deep equivalent dose measurements from thermos-luminescent dosimeters (TLDs) and dose per exam measurements from an electronic pocket dosimeter throughout the study, this research aimed to evaluate the occupational exposure of nuclear medicine workers with 18F-FDG. Over six months, the technologist, medical physicist, and nurse received (Mean±SD) whole-body radiation doses of (3.15±0.16, 2.4±0.14 and 1.73±0.08) mSv, respectively, while the (Mean±SD) equivalent dose per each exam was (2.28±0.15, 1.74±0.11 and 1.25±0.08) µSv for the technologist, medical physicist, and nurse, respectively.

Key Words: Positron Emission, Equivalent Dose, TLDs.

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Introduction

PET paired with CT is among the most significant of medical imaging modalities because of its unique ability to correctly identify and stage a wide range of cancers as well as track therapy progress[1]. 18 F-fluorodeoxyglucose is the most regularly utilized radiopharmaceutical (18F-FDG) [2]. [3] The PET/CT is becoming more widely used for screening purposes and the strong penetrating capacity of 18F(511 Kev) leads to a high whole body dosage to the employees while doing FDG PET/CT examinations. Operations involving the use of 18F-FDG, such as the preparation and administration of radiopharmaceuticals, in addition to patient placement and monitoring through 18F-FDG PET/CT scanning [4], [5], [6], [7]. Because new imaging techniques are being used and new measures of medical staff dosages are required [8], [9]. This has prompted various research to improve medical staff's perception of radiation dosage levels when employing PET/CT exams [10], [11], [12], [13]. The purpose of this study was to determine the radiation doses received by medical personnel and strategies to lower occupational exposure. Concerning radiation doses, radiation personnel

differs from the general population in the following aspects when it comes to occupational radiation exposure: [15] They're conscious that they might get extra doses at a job; [16] They've had radiation safety training; [17] They are committed to more stringent medical oversight than the majority of other employees; [18] Their exposures are tracked, and different safeguards are used to keep their doses to a bare minimum [19].

Materials and Methods

To evaluate the radiation dose from exposure to external radiation, each person (technologist, physicist, and nurse) carried two dosimeters at chest level (TLD badge and electronic dosimeters) throughout an FDG PET/CT exam. The workgroups spend eight hours daily, six days per week. Over 6 months period of study, the working group handled 18F-FDG with total activity 411.996 GBq administrated to 1383 adult patients with 18F-FDG activities from 275 to 315 MBq with an average activity of 297.9 MBq/patient during 18F-FDG PET/CT imaging in PET/CT unit in Cairo, Egypt in 2017.

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Around (297.9 MBq/patient) (8 mCi) of 18F-FDG was injected for adult patients' wholebody PET/CT scanning. Per whole-body scan, the total acquisition duration ranges from 20 to 25 minutes. Daily, 8–12 patients are imaged on this scanner.

During five consecutive 18F-FDG PET steps, radiation dose assessment was performed with both TLD dosimeters and EPD [(DoseRAE (ver2-04.07))] for multi-dose 18F-FDG packing (from syringe filling to patient departure). 2-[18F] fluoro-2-deoxy-D-glucose (18F-FDG) is the radiopharmaceutical used in the PET/CT unit. The multi-dose vial arrived at the institute at about 8:30 am from the owner company of the cyclotron. The multi-dose vial arrived at the institute in a lead container, and it was placed in the hot laboratory. After that, the daily routine at the unit begins with the workers. They were allocated to cover a workday from 8:00 A.M. to 5:00 P.M. and completed their tasks as follows:

1. The Medical Physicist

Assigned to the hot laboratory for dosage preparation. Within 1.001±0.277 minutes by drawing up the dose described to each patient from (18F-FDG) in a syringe based on the weight of the patient and physical health conditions, using a dosage calibrator to test the activity, then manually transferring it to a shielded transit box. Dose preparation was prepared behind a benchtop shield.

2. The Nurse

Assigned for injection of the prescribed dose of (18F-FDG) to each patient within 0.557±0.205 minutes, and patients must wait 30-45 minutes during the uptake period after the nurse has left the patient's injection room.

3. The Technologist

Assigned to all 18F-FDG PET/CT scanning tasks [escorting the patient to the scanner room after voiding in a reserved bathroom, placing, capturing

images, and assisting the patient during the examination and until it is ended], he spent (25.26±0.898 minutes) in direct contact with the injected patient.

PET/CT procedures require patient participation in the form of preparation, administration of radioactive drugs or parental route, explanation of the technique, and consoling and reassuring the patients [9]. The adult patient is given the radiopharmaceutical while lying in a waiting room bed and advised to wait for 30-45 minutes. He/she is instructed to empty his or her bladder before beginning the examination. After the PET/CT examination, the patient changes and exits the department. [20] Two (TLDs card, EPD) dosimeters were used for each job of 18F-FDG PET/CT scan, one for estimation the wholebody radiation dose and the other for evaluating the equivalent dose. During all 18F-FDG PET/CT procedures, medical personnel's occupational exposure was gathered and recorded.

Results and Discussions

In the present study, the workgroup examined 1383 patients with administered activities (411.996 GBq). The radiation dose (Mean±SD) for the staff was the following: The technologists received 3.15±0.16 mSv, as a whole-body dose, the medical physicist received 2.4±0.14 mSv as a whole-body dose, and the nurse received 1.73±0.08 mSv, as a whole-body dose. Throughout the six months of the present study, TLD cards were read every three months.

The radiation doses for the medical workers were increasing with the increase in the number of patients and the amount of the tracer. The technologist received the highest mean radiation doses compared with the medical physicist and nurse. Table 1 shows the dosages received by medical professionals and the average time spent, while Figures 1 and 2 demonstrate the contrast between each worker.

Table 1. Dosimetric evaluation for the medical staff throughout six months measured by TLDs

Nuclear Medicine Institute	Workgroup	No. of patients	Time spent (min.)	18F-FDG activity used	Total time study	(TLDs) (mSv)
	Physicist	8 - 12 daily	1.001±0.277	275- 315 MBq	6 months	2.4±0.14
	Technician		25.26±0.898			3.15±0.16
	Nurse		0.557±0.205			1.73±0.08



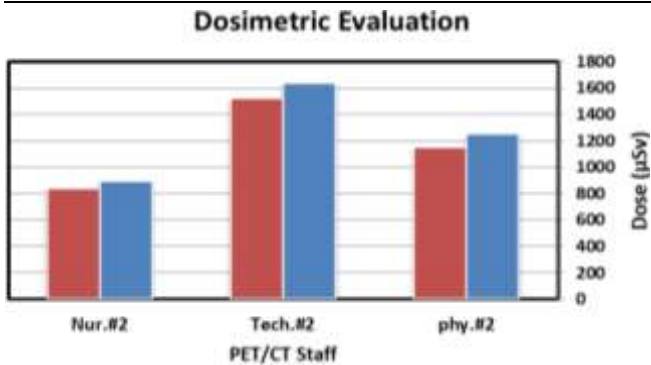


Fig. 1. Dosimetric evaluation of the medical staff for three months period measured by TLDs

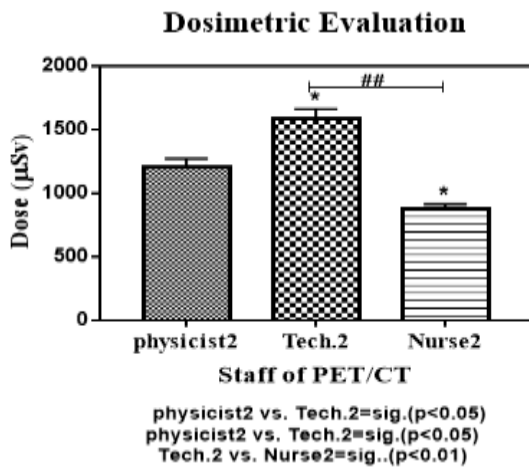


Fig. 2. TLDs (Mean±SD) dose measurements of the medical staff

As indicated in table 1, the difference in doses is according to their assigned jobs. Unsurprisingly, the technologist received a larger mean radiation dose per exam than other staff, which is likely due to time spent near a patient (4 to 8 minutes). The stages for medical physicists and nurses are shorter and can be performed behind a bench-mounted lead shield, suggesting that the procedures for preparing and supervising all imaging techniques result in a higher dose than the injection process. Nurses received the least amount of radiation because they spent the least amount of time dealing with radioactive materials.

Medical staff receives an effective wholebody dosage of 18F-FDG while doing tasks. During the six-month trial, EPD [DoseRAE (ver2-04.07)] was used to measure PET/CT procedures monthly. EPD (Mean±SD) dose measurements for the workgroup through 18F-FDG PET/CT procedure of (230.5±15.78) patients, administered activities (68666±6154) MBq were (401.8±26.5, 527.2±36.06, 289.8±20.17) µSv/month for a medical physicist, technologists, and nurse respectively, as shown in Table 2 and the Table 3. The estimated dose per (day, patient, administered activity)

comparison between each effective whole-body doses received by staff is shown in Figures 3 and 4:

Table 2. Average (patients & activities) per month and (Mean±SD) dose measurements using EPD

Nuclear Medicine Institute	Workgroup	No. of patients/ month	Activities/ month (MBq)	EPD µSv/m onth
		Mean±SD	Mean±SD	Mean±SD
Nuclear Medicine Institute	Physicist	230.5±15.78	68666±6154	401.8±26.5
	Technician	230.5±15.78	68666±6154	527.2±36.06
	Nurse	230.5±15.78	68666±6154	289.8±20.17

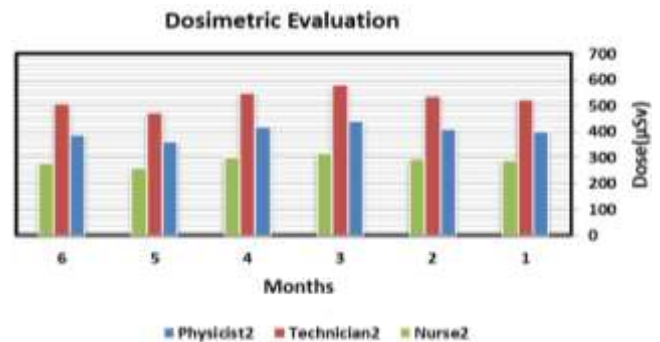


Fig. 3. Dosimetric evaluation of the medical staff for six months period measured by EPD

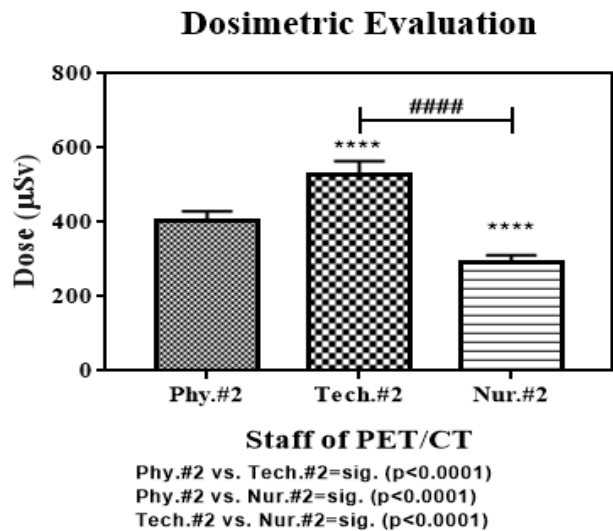


Fig. 4. EPD (Mean±SD) dose measurements of the medical staff for six months period

The radiation dosage per (patient, day, administered activity) for all personnel was calculated and reported in Table 3.



Nuclear Medicine Institute	Workgroup	Dose per patient (μSv/patient)	Dose per day (μSv/day)	Dose per administered activities (μSv/MBq)
	Physicist	1.74±0.11	16.74±1.10	0.0058±0.0004
	Technician	2.28±0.15	21.96±1.50	0.0076±0.0005
	Nurse	1.25±0.08	12.07±0.84	0.0042±0.0003

The effective dosage to PET/CT technologists was higher than in conventional nuclear medicine investigations [21], [22], [5], [23]. Direct comparisons of radiation doses received by medical staff among PET services, on the other hand, are insufficient to acquire a thorough understanding of variations in radioprotection circumstances and treatment. As a result, instead of focusing on radiation dosage, this study focused on the relationship dose per handled radioactivity in (Sv/MBq).

The technologist's dosages recorded with EPD are lower than those reported in [24], [25].

Because each PET/CT facility has a different set of condition factors, for example, patient doses, technique, personnel performance, and shielding devices, comparing these doses between institutions is challenging. Furthermore, comparing radiation doses received by medical workers across PET/CT services is insufficient to provide a thorough grasp of radioprotection situations and treatments. To keep clinical and radiation exposure to a bare minimum, it's necessary to have a solid awareness of radiation protection and safety hazards.

Conclusions

The staff work safely within established occupational radiation dose safety requirements to which they are routinely exposed, and the personnel dose values are substantially lower than the recommended annual ICRP dosage limit.

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