

# Occupational Radiation Exposure to Workers Used 18F-DG

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## Abstract

The increasing interest of medical institutes in the development of imaging services to include the hybrid system [Positron Emission Tomography combined with Computed Tomography (PET/CT)], this system is acquiring explosive growth due to its ability to accurately detect and stage many types of cancer and follow the progress of treatments. An increasing demand for use of (18F-FDG PET) in oncology has been the main reason for its growth. The physical characteristics of positron emissions result in higher radiation risk for staff and growing use of PET/CT for diagnostic purposes increase radiation exposure.

The objective of this study was to estimate the radiation exposure to the medical physicists, technicians and nurses working in three Egyptian nuclear medicine institutes under our investigations, based on the whole body collective dose measured by thermoluminescent dosimeters (TLDs) and the effective dose per study received by medical staff were measured by electronic pocked dosimeters and the finger doses by ring dosimeter during a period of six months. The (mean± SD) dose measured per PET/CT procedure were (2.45±0.137, 3.22±0.218 and 1.69±0.11) µSv for the medical physicist, technician and nurse respectively. The (mean± SD) dose measured per MBq of 18F-FDG were (7.35±0.43, 9.73±0.66 and 5.13±0.33) nSv/MBq for the medical physicist, technician and nurse respectively. The (mean± SD) finger dose measured per 18F-FDGPET/CT scans were (179.9±24.94, 8.82±2.912 and 24.15±4.164) µSv for the medical physicist, technician and nurse respectively

**Keywords:** PET/CT, Radiation Dose, 18F-FDG.

## Introduction

(PET/CT) is considered one of the most relevant diagnostic imaging techniques having the peculiar characteristic to provide both functional and morphological information of the organ of interest[1] PET/CT has become a widely accepted and frequently used imaging modality[2]. Combined PET/CT improves diagnostic accuracy in comparison with PET alone[3][4]. PET/CT is most commonly performed with 18F-FDG, which has a half-life of 109.8 minutes. Fluorine-18 is a positron emitting radionuclide that leads to an annihilation reaction of a positron and electron, producing two 511 keV photons. The 511 keV annihilation photons are much more highly penetrating than other diagnostic radiations [5].

It has been known for many years that the radiation exposure to staff performing PET studies is higher than conventional nuclear medicine imaging[6][7]. The increasing numbers of PET studies for routine diagnosis creates a real hazard to radiation workers[8]. Since new techniques of imaging are used and new measurements concerning the doses to medical staff are needed[9]. This has motivated several studies for better perception of the radiation dose levels received by medical staff under taking imaging with positron-emitter tracers[10][11][12].

The aim of this study was to measure the occupational radiation exposure of medical staff working in three Egyptian nuclear medicine institutes.

It has been necessary for staff to modify their working practices in order to minimize radiation exposure. After effective shielding of syringes, vials, transmission and quality control sources, attention has turned to minimizing the exposure to staff from patients. Education of staff on the importance of distance and time is a key factor in dose control [5][13].

## Materials and Methodologies

### *PET/CT Institutes*

The present study was carried out in three nuclear medicine (NM) institutes in Cairo, Egypt, presenting significant differences in their layout and radiation protection issues, but employing only [18F]-FDG in their PET/CT exams.

### *Dosimeters*

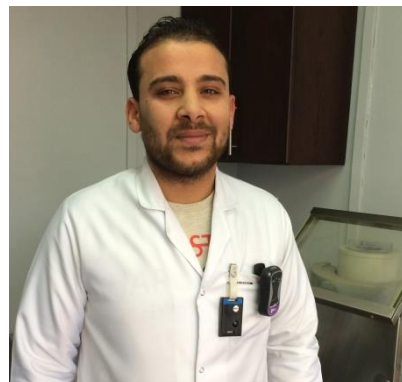
For measuring the whole-body dose and skin dose, medical workers were supplied with TLDs [100 TLD with lithium fluoride (LiF) detector annealed up to 3000C by Harshaw 6600 reader] and electronic pocked dosimeters [DoseRAE (ver2-04.07)] which having a dose sensitivity of [0 $\mu$ Sv to 9.99 Sv (0 $\mu$ R to 999 R), dose resolution ( $\leq 0.02 \mu$ Sv ( $\leq 2 \mu$ R))] worn at the upper pocket of their overall as shown in Figure 1. Prior to the measurements, all dosimeters had been calibrated at 660 keV with a <sup>137</sup>Cs source in the Egyptian national institute for standards. Ring [gamma-ray, x-ray only <15keV photons; dose range 300  $\mu$ Sv to 10 Sv] dosimeters were employed to measure finger radiation doses to PET/CT staff. These dosimeters were particularly suitable for this investigation.

### *Individual Monitoring*

In each 18F-FDG PET/CT image, one medical physicist, one nurse and one technologist worked together to cover their indicate duties. During each individual task, three (TLDs card, EPD, Ring) dosimeters were worn by medical staff: one for measuring the whole-body collective dose, second for measuring effective dose and third to measure finger radiation dose for each task dose. TLDs cards

were read periodically every three months by Harshaw 6600 reader in the Egypt national institute for standards and recorded the data through 6 months period of study, while the EPD [DoseRAE (ver2-04.07)] dosimeters were read monthly and recorded during period of study, ring dosimeters were worn for one months from all medical physicists, technicians, nurses similar to the whole-body measurement. However, we were able to measure finger doses of each PET/CT procedure to medical workers and recorded. In the three investigated nuclear medicine institutes, the procedure of setting up an intravenous line has been performed prior to administering the tracer to patient. The following tasks concerning PET/CT procedures were investigated:

1. Drawing up aradiopharmaceutical.
2. Injecting the radiopharmaceutical.
3. All PET/CT imaging (escorting, positing, acquiring images and helping the patient during and until the study is completed).



**Figure 1:** Example of positioning of the TLDs and EPD dosimeters.

## Results and Discussion

### *The Whole Body Collective Dose*

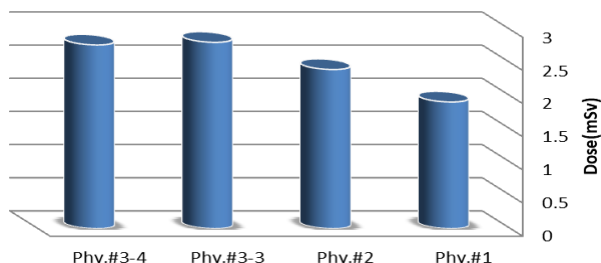
Over 6-months for a total of 144 working days period of study, the whole-body collective doses of the PET/CT staff for three institutes involved in 18F-FDG PET/CT procedure were measured with the use of TLDs dosimeters and reported in Table 1 and the comparison between them is shown in Figures 2,3 and 4.

**Table 1:** Dosimetric evaluation of the PET/CT staff in three institutes for a 6 months period measured by TLDs.

Institutes	No. of Patients/day	Administered activities/patient MBq	Physicist TLDs (mSv) (Mean±SD)	Technician TLDs (mSv) (Mean±SD)	Nurse TLDs (mSv) (Mean±SD)
Institute #1	4-6	300-350	1.91±0.014	2.64±0.17	1.2±0.113
Institute #2	8-12	275-315	2.4±0.14	3.15±0.16	1.73±0.08
Institute #3-3	13-15	333-355	2.81±0.071	3.61±0.099	1.99±0.042
Institute #3-4	13-15	333-355	2.77±0.042	3.58±0.084	2±0.084

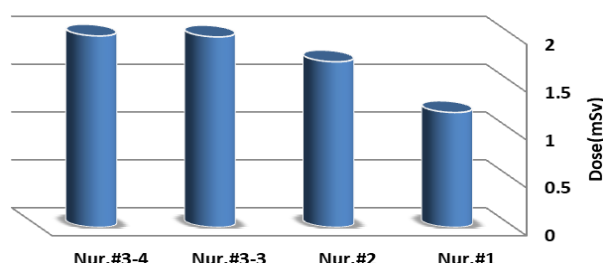
#3-3 means: Third institute-first group. #3-4 means: Third institute – second group.

**Dosimetric Evaluation**



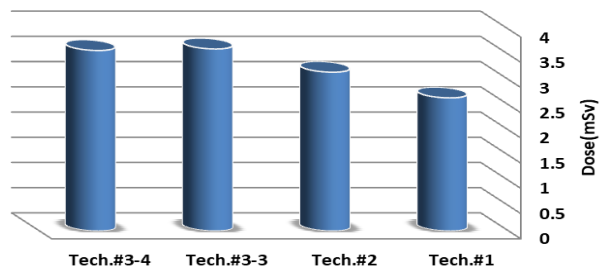
**Figure 2:** Dosimetric evaluation of the medical physicists in three institutes for a 6 months period measured by TLDs.

**Dosimetric Evaluation**



**Figure 4:** Dosimetric evaluation of the nurses in three institutes for a 6 months period measured by TLDs.

**Dosimetric Evaluation**



**Figure 3:** Dosimetric evaluation of the technicians in three institutes for a 6 months period measured by TLDs.

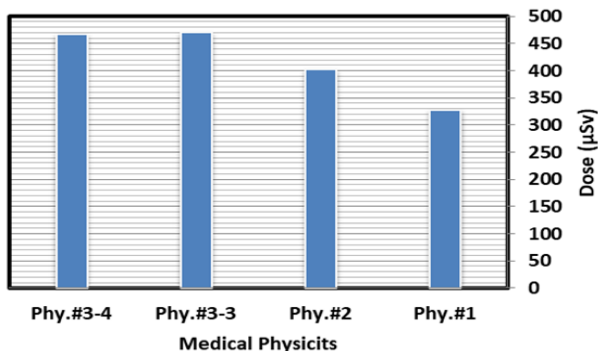
**Effective whole-body dose**

Effective whole-body dose to nuclear medicine staffs in three institutes during performing duties with 18F-FDG PET/CT procedures were measured monthly with the use of EPD during a 6 months period of study and reported in Table 2 and the comparison between them is shown in Figures 5, 6 and 7:

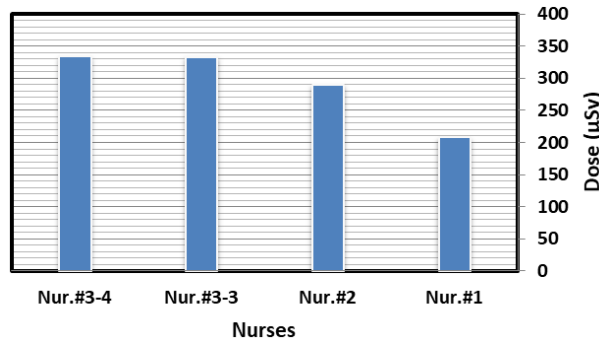
**Table 2:** Dosimetric evaluation of the PET/CT staff in three institutes for a 6 months period measured by EPD.

Institutes	No. of Patients/month (Mean±SD)	Administered activities/month (GBq) (Mean±SD)	Physicist μSv/month (Mean±SD)	Technician μSv/month (Mean±SD)	Nurse μSv/month (Mean±SD)
Institute #1	130±11.52	42.199±4.656	327.83±34.84	449.33±60.59	207.5±24.24
Institute #2	230.5±15.78	68.666±6.154	401.8±26.5	527.2±36.06	289.8±20.17
Institute #3-3	168±4.243	58.244±2.187	470.3±14.51	607.2±18.14	333.2±13.57
Institute #3-4	169.5±5.612	58.522±2.575	466.7±15.58	603.2±26.76	333.8±17.08

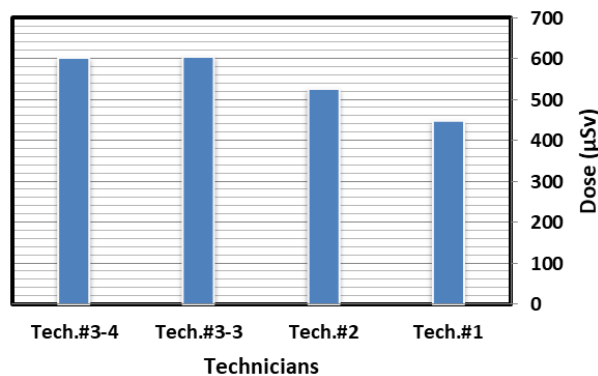




**Figure 5:** Dosimetric evaluation of the medical Physicists in three institutes for a 6 months period measured by EPD.



**Figure 7:** Dosimetric evaluation of the nurses in three institutes for a 6 months period measured by EPD.



**Figure 6:** Dosimetric evaluation of the technicians in three institutes for a 6 months period measured by EPD.

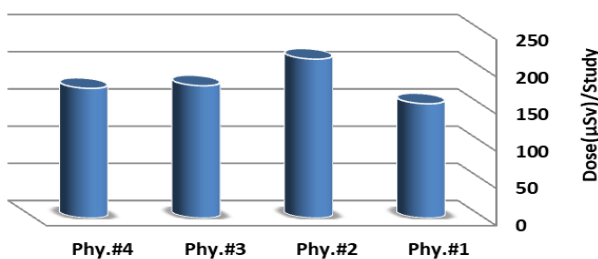
**Finger doses**

Finger radiation doses to the PET/CT staffs in three institutes during cover their indicate duties with 18F-FDG PET/CT procedures were measured during one month with the use of ring dosimeters and reported in Table 3 and the Comparison between them is shown in Figure 8, 9 and 10:

**Table 3:** Finger doses to nuclear medicine staffs in three institutes while performing duties with 18F-FDG PET/CT procedures.

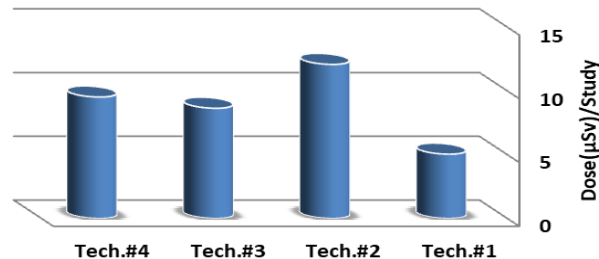
Institutes	No. of procedures	Administered activities (MBq)	Physicist µSv/study	Technician µSv/study	Nurse µSv/study
Institute #1	124	325±25	153.7	5.04	19.67
Institute #2	240	295±20	213.75	12.08	29.5
Institute #3-3	162	344±11	177.9	8.64	24.93
Institute #3-4	168	344±11	174.4	9.52	22.5

**Finger Doses**

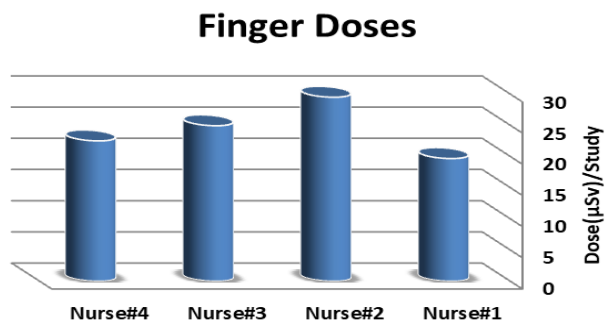


**Figure 8:** Finger doses of the medical physicists in three institutes during one month period measured by ring dosimeter

**Finger Doses**



**Figure 9:** Finger doses of the technicians in three institutes during one month period measured by ring dosimeter



**Figure 10:** Finger doses of the Nurses in three institutes during one month period measured by ring dosimeter.

The radiation dose to the workers in PET/CT units mainly arises from handling of the 18F-FDG (preparation, injection) and from close contact to the patients after injection. The radiation exposure may be affected by many reasons such as the amount of the administered activity and the number of patients, mobility of patients and their physical health condition, workers experience, individual skills, training, imaging protocol and work practice.

International commission on radiological Protection 2007, recommendations of the international commission on radiological protection (ICRP) Publication 10320 mSv per year for whole-body and 500 mSv per year for fingers[14].

There were several reports on whole-body dose per study in the literature; such as 8.9 µSv by Zeff *et al.*, 8.5 µSv by Chiesa *et al.*, 6.5 by Benetar *et al.*, and 7.2 µSv by Biran *et al.*.

It is difficult to compare these doses between institutes because of the variability in the condition factors in each individual PET/CT facility, such as the patient doses, the procedure, the staff performance and shielding devices.

In three nuclear medicine institutes, technician was the highest radiation dose compare with another medical workers and this increasing due to the longer time spent near the patients during all PET/CT imaging tasks.

Finger doses were found to be within permissible limits. The highest finger dose to physicist are likely from handing of the 18F-FDG multi-dose syringe, transferring the dose to the injection room and measuring the post-injection residual dose in the syringe. The

nurse performed shorter part with ready-made individual radiopharmaceutical syringe and pre IV for administration. Although, technician spent the maximal time per study, however, they have the lowest finger dose because they did not directly handle the radioactive material. An understanding of the radiation protection and safety issues are very important to keep clinical and occupational exposure as low as reasonably achievable (ALARA)[15].

## Conclusion

When compared with the ICRP dose limit, each individual worker can work with many more 18F-FDG PET/CT studies for a (period time) without exceeding the occupational dose limits. This study confirmed that low levels of radiation doses are received by our medical staff involved in 18F-FDG PET/CT procedures.

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