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Dose Measurements for Worker Used 18F-FDG

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Abstract

Positron Emission Tomography combined with Computed Tomography (PET/CT) which has been playing key role in medical applications and explosive growth of PET/CT scans creates health hazard real on the radiation workers. The objective of this study was to measure the radiation exposure to the medical physicists, technicians and nurses working in three Egyptian nuclear medicine institutes based on the deep equivalent dose measured by thermoluminescent dosimeters (TLDs) and the dose per exam was measured by electronic pocked dosimeter during period of study. The (Mean±SD) whole body radiation dose during six months period was (2.47±0.066, 3.24±0.128 and 1.73±0.079) mSv for the Medical physicist, technician and nurse respectively, while the (Mean±SD) dose measured per PET/CT procedure was (2.45±0.139, 3.22±0.218 and 1.69±0.11) μSv for the Medical physicist, technician and nurse respectively. This study confirmed that low levels of radiation doses are received by the medical personnel involved in 18F-FDG PET/CT procedures.

Key words: PET/CT, Radiation Exposure, TLDs.

INTRODUCTION

Positron Emission Tomography is considered to be one of the most relevant diagnostic imaging techniques having peculiar characteristic to provide both functional and morphological information for the patient (Dalianis, *et al.* 2015).The most commonly used radiopharmaceutical is 18 F- Fluorodeoxyglucose (18F-FDG). (Dalianis, *et al.* 2006) Increasing number of 18F-FDG PET/CT studies and the high penetrating ability of 18F raised the issue of radiation doses to medical staffs while performing their duties with 18F-FDG PET/CT procedures i.e. preparation, handling and administration of the radiopharmaceuticals as well as patient positioning and monitoring during routine PET/CT examinations (Chiesa, *et al.* 1997), (Guillet, *et al.* 2005), (Roberts, *et al.* 2005) .Since new techniques of imaging are used and new measurements concerning the doses to medical staff are needed (Amaral, *et al.* 2007). This has motivated several studies for better perception of the radiation dose levels received by medical staff undertaking imaging with positron-emitter tracers (Wu, Liu *et al.* 2000), (Schleipman, *et al.* 2006), (Seierstad, *et al.* 2006). The aim of this study was to measure the occupational radiation exposure of medical staff working in three Egyptian nuclear medicine institutes. With respect to radiation exposures, radiation workers differ from other members of the general public: (Kim, Miller *et al.* 2008) they are aware that they may receive additional doses at work, (Kuipers and Velders 2009) they are trained in radiation protection, (Persliden 2005) they are under stricter medical surveillance than most workers in other fields**,** (Vano, *et al.* 1998) there are monitored and various protection measures are implemented to keep their exposures to the lowest possible levels and not exceeding certain limits.

MATERIALS AND METHODS

Present study was carried out in three nuclear medicine (NM) institutes in Cairo, Egypt , presenting significant differences in their layout and radiation protection, but employing only [18F]-FDG in their PET/CT exams. Three Nuclear medicine institutes have four groups work, each group consist of one medical physicist, one technician and one nurse. The first and second work groups spend 8 hours daily for six days per week while third and fourth work groups spend 9 hours daily for 3 days per week during 6 months study period. .Radiation dose assessment was performed for multidose 18F-FDG packaging with both LiF thermoluminescence dosimeters (TLD) and electronic personal dosimeters [(DoseRAE (ver2-04.07)] during 5 successive 18FFDG PET steps (from syringe filling to patient departure). The radioactive material handled in PET/CT institutes is 2-[18F] fluoro-2- deoxy-D-glucose (18F-FDG). It was received at about 8:30 Am from the owner company of the cyclotron, the multi dose vial arrives to the institute in a (7 cm) thick lead shielded container and it was placed in the hot laboratory. After that, the daily routine at the unit begins by workers; they were assigned to cover a workday from 8:00 AM to 5:00 PM and carried out their assigned duties hence (1) the medical Physicist was assigned for dose preparation at the hot lab. within 1.225±0.177 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 dose calibrator to assay the activity then transferred manually to shielded transported box and measuring the post-injection residual dose in the syringe. Dose preparation was performed behind a bench top shield. (2) nurse was assigned for injection of prescribed dose of (18F-FDG) to each patient within 0.62±0.059 minutes and leave immediately the patient's injection room and patients wait during uptake phase from 30-45 minutes. (3) technician was assigned for all PET/CT imaging tasks [escorting the patient to the scanner room after voiding in a reserved bathroom, Positioning, Acquiring images and helping the patient during and until the study is completed] , he was spend 6.809±1.053 minutes in direct contact with the injected patient. Nuclear Medicine procedures require patient interaction relating to patients preparation administration of radioactive medication or parental route, explaining the procedure comforting and reassuring the patients (Amaral,*et al.*2007). Patient is injected with the radiopharmaceutical lying in a bed in the waiting area and he/she is asked to wait for 30-45 minutes. Before the beginning of the examination, the patient is asked to empty the bladder. The PET/CT examination last for about 20-30 minutes and then the patient, after changing, leaves the department.(Benatar *et al.* 2000) During each individual task of 18F-FDG PET/CT scans, three (TLDs card, EPD) dosimeters were worn by medical staff at chest level: one for measuring the whole-body collective dose and second for measuring effective 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 [Dose RAE (ver.2-04.07)] dosimeters were read monthly and recorded during period of study. We were able to measure finger doses to medical workers for one month and recorded by using ring dosimeters, the occupational exposure for each group was collected and recorded during all 18F-FDG PET/CT procedures.

RESULTS AND DISCUSSIONS

In the present study, the first work group examined 780 patients with administrated activities 253.194 GBq ,second work group examined 1383 patients with administrated activities 411.996 GBq, third work group examined 1008 patients with administrated activities 349.465 GBq and fourth work group examined 1017 patients with administrated activities 351.133 GBq. The whole body dose (Mean±SD) for the first six months to the medical workers were the following: Nurse #(1) received 1.2±0.113 mSv, Nurse #(2) received 1.73±0.08 mSv, Nurse #(3) received 1.99±0.04 mSv and Nurse #(4) received 2±0.08 mSv as a whole body dose respectively. Medical Physicist # (1) received 1.91±0.014 mSv, Medical Physicist # (2) received 2.4±0.14 mSv, Medical Physicist # (3) received 2.81±0.071 mSv and Medical Physicist # (4) received 2.77±0.04 mSv as a whole body dose respectively. Lastly, Technician # (1) received 2.64±0.17mSv, Technician # (2) received 3.15±0.16 mSv, Technician # (3) received 3.61±0.09 mSv and Technician # (4) received 3.58±0.08 mSv as a whole body dose respectively. TLDs were read every 3 months and the prospective annual dose for them indicate that the annual dose to PET/CT staff increases with the number of patients and administered activities as shown in **Table** 1 and the comparison between each group is shown in **Figures** 1,2,3 and 4:

Table 1: TLDs dose measurements & prospective annual dose of three institutes.

	Work groups	No. of patients/3months	Administered activities/3months (GBq)	TLDs µSv/3months	Prospective annual dose (mSv)
Institute #1	Physicist#1	390±14.14	126.6±6.25	955±7.07	3.82±0.02
	Technician#1			1320±84.85	5.28±0.34
	Nurse#1			600±56.57	2.4±0.22
Institute#2	Physicist#2	691.5±31.82	205.998±13.35	1200±70.71	4.8±0.28
	Technician#2			1578±82.02	6.31±0.32
	Nurse#2			867.5±41.72	3.47±0.16
Institute #3	Physicist#3	504±8.485	174.733±4.157	1405±35.36	5.62±0.14
	Technician#3			1805±49.5	7.22±0.19
	Nurse#3			995±21.21	3.98±0.08
	Physicist#4	508.5±6.364	175.567±3.574	1385±21.21	5.54±0.08
	Technician#4			1790±42.43	7.16±0.16
	Nurse#4			1000±42.43	4±0.16

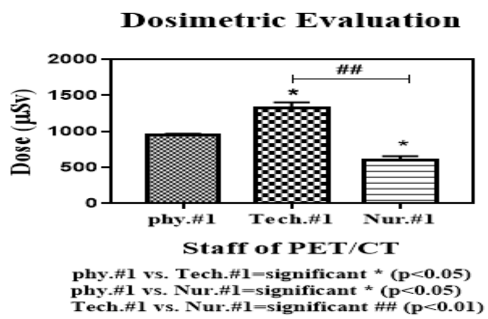

Fig. 1: TLDs (Mean±SD) dose measurements of the institute #1.

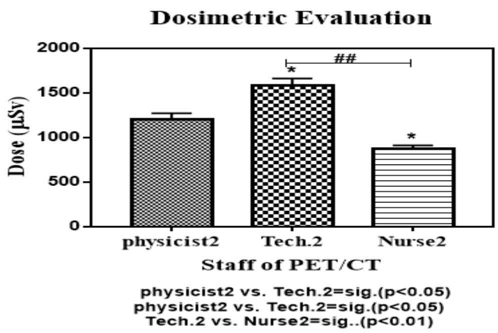

Fig. 2: TLDs (Mean±SD) dose measurements of the institute #2**.**

The difference in doses is attributed to their assigned duties, as shown in table 1, unsurprisingly, the mean effective whole-body dose per study received by technicians were higher than other personals which are likely to depend on time spent in proximity to a patient (4 to 8 minutes). High radiation doses may also imply that their patients need more attention, therefore, more contact time, in contrast, the steps of the procedures for medical physicist and nurses are shorter and could be performed behind a bench mounted lead shield, which indicates that the preparation and supervision processes for all imaging procedure leads to a higher dose than that the injection process. The radiation dose received by nurses were the lowest, this attributed to the least time spent in dealing with radioactive material. In previous studies, the radiation dose is measured in K. Dalianisa, *et al*., (Dalianis, Kollias *et al*. 2015), the whole body dose for the medical workers during six months were the following: Nurse received 1.1–1.3 mSv, medical physicist received 1.9–2.2 mSv and technologist received 1.1-1.4 mSv respectively raised from imaging 6-8 patients per day and injected activity/patient varied from 330-390 MBq. Effective whole-body dose to medical staff: in three institutes during performing duties with18F-FDG PET/CT procedures were measured monthly with the use of EPD [DoseRAE (ver2-04.07) during a six months period of study, EPD (Mean±SD) dose measurements for first group through 18F-FDG PET/CT procedure of (130±11.52) patients, administered activities (42199±4656)MBq were (327.83±34.84, 449.33±60.59, 207.5±24.24) µSv/month for medical physicist#1, technician#1 and nurse#1 respectively , (Mean±SD) dose measurements for second group 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 medical physicist#2, technician#2 and nurse#2 respectively, (Mean±SD) dose measurements for third and fourth groups through 18F-FDG PET/CT procedure of (168±4.243),(169.5±5.612) patients, administered activities (58244±2187),(58522±2575) MBq were (470.3±14.51, 466.7±15.58, 607.2±18.14, 603.2±26.76, 333.2±13.57, 333.8±17.08)) µSv/month for medical physicist#3,4; technician#3,4; nurse#3,4 respectively, and calculate the radiation dose per (patient, day, MBq) for all groups and reported in **Table** 2**.**

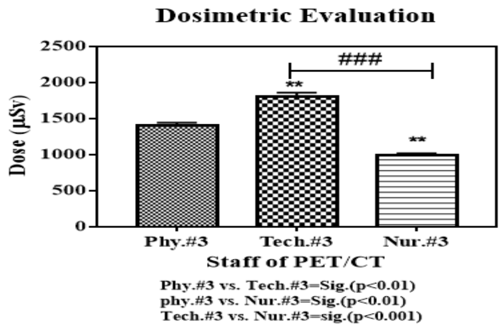

Fig. 3: TLDs (Mean±SD) dose measurements of the institute (#3-3)*.
(#3-3)*: (Third Institutes, third group)

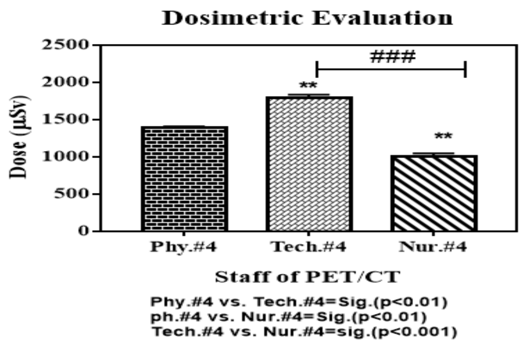

Fig. 4: TLDs (Mean±SD) dose measurements of the institute (#3-4)*.
(#3-4)*: (Third institute, fourth group)

Table 2: The estimated dose per (day, patient, administered activity) of three institute using EPD**.**

	Work Group	**Dose per patient (µSv/patient)**	**Dose per day (µSv/day)**	**Dose per administered activities (µSv/MBq)**
Institute #1	Physicist#1	2.52±0.26	13.6±1.45	0.0077±0.0008
	Technician#1	3.45±0.46	18.7±2.52	0.0106±0.0014
	Nurse#1	1.59±0.18	8.6±1.01	0.0049±0.0005
Institute #2	Physicist#2	1.74±0.11	16.74±1.10	0.0058±0.0004
	Technician#2	2.28±0.15	21.96±1.5	0.0076±0.0005
	Nurse#2	1.25±0.08	12.07±0.84	0.0042±0.0003
Institute #3	Physicist#3	2.79±0.086	39.19±1.209	0.008±0.00025
	Technician#3	3.61±0.107	50.6±1.512	0.0104±0.00031
	Nurse#3	1.98±0.08	27.76±1.13	0.0057±0.00023
	Physicist#4	2.75±0.092	38.89±1.29	0.0079±0.00026
	Technician#4	3.55±0.157	50.26±2.23	0.0103±0.00045
	Nurse#4	1.96±0.101	27.81±1.42	0.0057±0.00029

It has been observed that the radiation exposure doses to technician working in PET/CT studies are higher than for conventional nuclear medicine (Clarke, Thomson *et al*. 1992), (Harding *et al*.), (Harding, *et al*. 1990), (Chiesa, *et al*. 1997) and (Clarke, *et al*. 1997). However, the direct comparison of doses received by medical staff among PET services is not enough to obtain good perception of nuances in radioprotection conditions and management. For this reason, it was decided, in this work, to analyze the relationship dose per handled radioactivity in (µSv/MBq) instead of radiation dose only.

The dose per study for the technician measured using EPD are lower than those doses as presented in (Taalab, *et al*. 2013) and (El-Din, Mahmoud *et al*.), (El-Din, Mahmoud *et al*. 2017). 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 additional, the direct comparison of doses received by medical staff among PET/CT services is not enough to obtain good perception of nuances in radioprotection conditions and management. Understandings of the radiation protection and safety issues are very important to keep clinical and occupational exposure as low as reasonably achievable.

Conclusions:

The personnel dose results are significantly lower than the recommended annual ICRP dose limit and this study confirmed that our staff works safely within recommended safety levels of occupational radiation doses to which they are routinely exposed.

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