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Occupational radiation dose for medical workers at Al-Makassed hospital

Muntaser S Ahmad[1*], Maysara Rumman[2], Ayoub O Zaghal[3], Khalid A Salman[4], Azzam Alarab[5], Ammar A Oglat[6], Hjouj Mohammad[7]
[1-5] Department of Medical Imaging, Faculty of Allied Medical Health, Palestine Ahlyia University, Dheisha, Bethlehem Palestine
[1] Department of Medical Physics and Radiation Science, School of Physics, Universiti Sains Malaysia, Penang Malaysia
[6] Department of Medical Imaging, Faculty of Apllied Medical Sciences, the Hashemite University, Zarqa, Jordan
[7] Medical Imaging Department, Faculty of Health Professions, Al-Quds University, Abu Deis - Main Campus, Jerusalem -Palestine

Abstract
Purpose: Occupational radiation dose monitoring is a method of ensuring that radiation levels are within the regulatory limits. Our objective in this study was to evaluate the radiation doses received by medical radiation workers at a radiology facility between 2012 and 2016.
Methods: A total of 90 medical radiation workers were monitored to determine the status of their average annual effective dose. The analysis and the calibration procedures of this study were carried out from the Soreq Nuclear Research Centre. The monitored workers were classified into subgroups, namely, technicians, and nurses according to their responsibilities and specialties. The doses were measured using thermo-luminescence dosimeters (TLD) placed over the lead apron at the chest level in all types of medical workers.
Results: The highest annual dose limits for radiologic technologists, radiologists, surgical nurses, catheterization nurse, orthopaedics, cardiologists, and anaesthesiologists were 0.16 mSv, 0.55 mSv, 0.41 mSv, 0.68 mSv, 0.76 mSv, 6.46 mSv, 4.97 mSv, respectively.
Conclusion: The results of the measured annual dose were well below the international recommended dose limit of 20 mSv.

Keywords: occupational radiation dose, dose limit, TLD, radiation protection, effective dose

1. Introduction

Newly, medical imaging technologies have been utilized in different applications, such as education, research, industry, agriculture, and medicine [1]. The increasing of population with improvement the health services has performed in an increased employ of medical imaging technologies in diagnosis and treatment purposes [2]. Medical and occupational exposure are considered as the main portion of the exposure in ionizing radiation exposed. The researchers focused on the cancer risk of the ionizing radiation by estimated the radiation absorbed dose through the body, also the researchers tried to establish a new model for determine the carcinogenic effects related to the low radiation dose [2, 3].

The International Commission on Radiological Protection (ICRP) aimed to supply a standard system for radiation protection in all aspects including medical, environmental, occupational, and controlling against radiological accidents (Emergencies accidents) [4, 6, 6]. The occupational exposures indicate to the worker exposure who exposed the ionizing radiation during the work, and this exposure including the natural and man-made sources [7, 8, 9, 10].

The recommendations for occupational workers in medical field to follow the safety standard of the International Atomic Energy Agency (IAEA). The estimation of dose for occupational exposures is play an essential factor for the organization to assess the risk of radiation for the workers and to build the suitable protective against the radiation [12].

The medicine staff members including the physicians, radiographers, nurses, cleaners, and other receive some of radiation doses during the working time. A lot of hospitals provide radiation exposures monitoring for those workers routinely [12, 13].

The limitation of the workers dose in the diagnostic medical imaging return into the two categories A and B, group A consists of workers who may obtain the effective dose less than mSv/ year, or an equivalent dose for eye less than mSv/year and less than mSv/year for skin and extremities, while group B consists of workers who may be exposed more than these values reaches to 20mSv/year [14, 15]. The devices used to measure the radiation dose called active personal dosimeters (APDs) and the most common device is Thermo luminescent dosimeters (TLDs). TLDs should put outside the lead apron to calculate the accurate dose measurements [17]. A high percentage of the procedures and operations are performed under x-ray imaging guidance such as C-Arm in operation rooms, Cath lab, Lithotripsy unit, in addition to radiology department. Radiation safety plan is on place to control the use of radiation in the different hospital wards, and all the radiation workers are committed to wear the radiation monitor devices (TLDs).

The main aims of this study was to check the annual occupational radiation dose history among the workers of Al Makassed hospital. The study concerned on four medical departments at Al

Makassed Hospital—radiology department, Catheterization laboratory, operation room and lithotripsy room—during the period from 2012 to 2016. The objective of this study was to track these departments' occupational dose history, to determine the highest exposure area and to check the radiation protection instructions carried out at these departments.

2. Materials and Methods

The study concentrated on four medical departments at Al Makassed Hospital in east Jerusalem—diagnostic, catheterization laboratory, operation room and lithotripsy room—during the period from 2012 to 2016, the medical radiation workers a total of 90workerswere classified into subgroups according to their responsibilities and specialties shown in table (1). In this study, thermoluminescent dosimeters (TLD) were used, all of TLDs containing Lif (Ti) crystals; also it will concentrate on whole-body doses or effective dose received by medical radiation workers in all the occupational categories.

All workers wear the TLDs in the front of chest region during their work; in the upper left side of the chest is essential area due to it receive the highest radiation exposure in whole body, the TLDs were put outside the protective lead apron. The background (control) reading was applied by choose one TLD outside the radiation field to make the calibration and quality assurance analysis. The calibration process was automatically and the dosimeters were taken to the reading centre in the Soreq Nuclear Research Centre after finish the measurement period to estimate the radiation dose measurements. To read the TLDs measurements, the TLD reader model 6600 was used. The effective dose as a whole body dose reading were taken for the period from 2012 to 2016.

The TLDs collected during the personal dose equivalents evaluation, and the reading was achieved quarterly. Two of TLDs was used to obtain the background radiation dose, and it was subtracted from the dose values which measured. The labels of TLD card contained a barcode number and the name of wearer person also the department. The calibration of TLDs was achieved in the Soreq Nuclear Research Centre.

Dosimeter reading data analysed by excel sheet, the monitored workers were classified into nine subgroups radiology technician, Radiologist, Surgical nurse, catheterization Nurse, orthopaedic surgeon, Neurosurgeon, Cardiologist, Anaesthesiologist, urologist according to their responsibilities and specialties. It is important to mention that all radiation workers were wearing lead aprons and thyroid shields while performing examinations, according to the radiation protection policy at Al makassed hospital in the fluoroscopy procedures and the TLD monitor was Under the Lead apron on the upper level of the chest.

Table 1: Number of radiation workers monitored in all occupational classification of medical departments at Al Makassed Hospital.

Occupational classification	Number of monitored workers
Radiology Technician	15
Radiologist	8
Surgical Nurse	37
Catheterization Nurse	7
Orthopaedic Surgeon	9
Neurosurgeon	6
Cardiologist	4
Anaesthesiologist	2
Urologist	2
Total Number Of Workers	90

3. Results and Discussion

3.1 Distribution of medical radiation workers

The dose distributions of radiation workers are used to determine the minimum level of exposure in the medical field according to ALARA principles. In Al Makassed Hospital, approximately 90 occupational radiation workers were monitored. The percentage distribution is as follows: radiology technician (17%), radiologist (9%), surgical nurse (41%), catheterization nurse (8%), orthopaedic surgeon (10%), neurosurgeon (7%), cardiologist (4%), anaesthesiologist (2%) and urologist (2%). Table 1 shows the number of radiation workers monitored in all occupational categories of medical departments during the period 2016. Fig. 1 shows the contribution from each type of medical radiation worker to the total monitored workers.

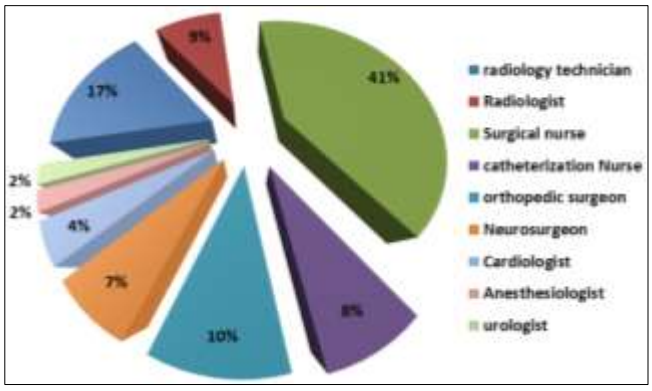

Fig 1: Contribution of each type of medical radiation worker to the total monitored workers.

The main results of this study showed that the occupational radiation doses for all the radiation working staff are extremely below the maximum permissible doses in reference to the ICRP. Distribution of the annual effective dose (mSv) by medical workers for different specialists.

Tabel2 shows that all the measured occupational annual doses for radiology technician workers in the period 2016 were well below the international recommended dose limit (20 mSv). 0.93 % of the radiology technician workers (N=14) TLD reading was approximately zero. The highest recorded frequency (0.16 mSv) is well below the recommended dose limit (20 mSv) as adopted from the ICRP recommendations

Table 2: Radiology Technicians Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Radiology Technician	1					
	2					
	3					
	4					
	5					
	6					
	7				0.14	0.14%
	8					
	9					
	10					
	11				0.1	0.10%
	12		0.16	0.80%	0.16	0.16%
	13					
	14					
	15				0.1	0.10%

Table 3 shows that the highest annual dose value recorded were 0.55 mSv, recorded by the chest TLD worn by one of the radiologists, which represents 2.75% of the annual recommended dose limit. A percentage of 87.5% of the radiologists (N=7) Annual dose were approximately zero.

Table 3: Radiologist Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Radiologist	1					
	2					
	3					
	4					
	5				0.11	0.11%
	6					
	7	0.14	0.55	2.75%	1.39	1.39%
	8					

The highest occupational radiation doses for medical staff were found to be those registered in fluoroscopy application. As seen in Table 4 the greatest number of Occupational medical workers monitored were the Cath-lab nurses present in (41%) of the percentage distribution of the occupational workers in almakassed hospital as shown in Fig. 1.

Table 4 shows that A percentage of 89% of the surgical nurses (N=33) Annual dose were approximately zero, remind occupational surgical nurses (N=4) annual doses ranged from 0.11 mSv to 1.12 mSv with in an average value of 0.41 mSv. All the surgical Nurses occupational radiation was well below the recommended dose limit (20 mSv) as adopted from the ICRP recommendations. there was a previous case with one of the surgical nurses' worker number 7 received an annual dose from one of the months in 2015 a high effective dose 110.89 mSv we investigated with the employee about this dose, we discovered that this high dose received the TLD because the TLD was missing from the employee, he found the TLD monitor after couple of days under the Fluoroscopy table, the TLD well received a primary radiation.

Table 4: Surgical Nurse Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Surgical nurse	1					
	2					
	3				7.78	7.78%

	4					
	5					
	6					
	7		0.27	1.35%	110.89	
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19		0.11	0.55%	0.11	0.11%
	20					
	21					
	22					
	23		1.12	5.6%	1.12	1.12%
	24					
	25					
	26					
	27					
	28					
	29					
	30		0.14	0.70%	0.14	0.14%
	31				0.3	0.30%
	32				0.1	0.10%
	33					
	34					
	35					
	36					
	37					

Table 5 shows the distribution of the annual dose for cath. Nurses workers, the annual effective dose ranged between 0.13 and 1.37 mSv with in an average of 0.68 mSv. The reminds received a recorded of approximately zero mSv. We can conclude that the workers in a catheterization laboratory are exposed to a relatively higher amount of radiation than radiology technicians' workers.

Table 5: Catheterization Nurse Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Catheterization Nurse	1				3.07	3.07%
	2	0.54	0.54	2.70%	0.64	0.64%
	3					
	4					
	5		0.13	0.65%	3.65	3.65%
	6	0.81	1.37	6.85%	4.37	4.37%

Table 6 shows that 0.77% of the orthopaedic surgeon (N=7) received an effective dose recorded of approximately zero mSv, the reminds ranged between 0.46 mSv and 0.76 mSv, these ranges still remind well below the international recommended dose limit (20 mSv).

Table 6: Orthopaedic Surgeons Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Orthopaedic surgeon	1					
	2				0.1	0.10%
	3					
	4					
	5					

	6					
	7				0.1	0.10%
	8		0.46	2.30%	0.46	0.46%
	9		0.76	3.80%	0.76	0.76%

Table 7: Neurosurgeons Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Neurosurgeon	1					
	2					
	3					
	4					
	5					
	6					

Table 7 shows that the Neurosurgeons workers (N=6) has a percentage of 100% Annual dose were approximately zero. It's important to mention that this category of workers has received a new TLD dosimeters in the end of the year and there were no data in the previous TLD records.

Table 8 shows that the cardiologist workers distributed on four workers, a couple of workers received an approximately zero mSv, the other two ranged between 0.7 mSv percentage from annual limit of20mSv (3.50%) and 6.46 percentage from annual limit of 20mSv (32. 30%).Cardiology is the most dynamic field in terms of medical exposure due to the application of diagnostic X-rays. Workers in the cardiology field have a high effective dose, the highest annual dose of all occupational received by one the cardiologist.

Table 8: Cardiologists Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose	Total Dose (100msv) For Five Years (%)
Cardiologist	1				15.84	15.84%
	2	0.24	0.7	3.50%	5.78	5.78%
	3					
	4		6.46	32.30%	6.46	6.46%

Table 9 shows that the highest annual dose of the anaesthesiologist was 4.97 mSv percentage from annual limit of 20mSv 24.85% and the 2nd anaesthesiologist annual dose was 2.13 mSv percentage from annual limit of 20mSv 10.65%, the average value of the annual doses for anaesthesiologist's workers was 3.55 mSv. We can conclude that the workers in anaesthesiology are exposed to a relatively higher amount of radiation than radiology technicians' workers.

Table 9: Anaesthesiologists Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose (2012-2016)	Total Dose (100msv) For Five Years (%)
Anaesthesiologist	1		2.13	10.65%	2.24	2.24%
	2	0.31	4.97	24.85%	4.97	4.97%

Table 10 shows that the urologist workers (N=2) has an approximately zero mSv annual dose received. Shock wave lithotripsy, percutaneous nephrolithotomy, endoscopic ureter stone treatments, and retrograde intracranial operations are frequently used minimally invasive treatment methods for ureter and kidney stones. During these minimal invasive methods, imaging techniques (e.g. fluoroscopy, ultrasonography, computed tomography) are usually used as guidance. The most commonly used technique is fluoroscopy.

Table 10: Urologists Workers Monitored.

	Worker No.	Current Annual Dose	Annual Dose 2016	Annual Limit Of 20msv (%)	Five Years Dose (2012-2016)	Total Dose (100msv) For Five Years (%)
Urologist	1					
	2					

4. Conclusion

The main purpose of this study was the evaluation of radiation doses received by radiation personnel according to permissible limits, the measured annual effective doses for the medical workers were much lower than the maximum permissible dose limits. The highest occupational radiation effective dose recorded in the period of 2016 was in the operation room category classified by one of the cardiologists with an annual dose of 6.46 mSv percentage from the annual limit dose of 20msv 32.30%. The occupational radiation dose received to the workers at four

different medical departments well below the recommended dose limit (20 mSv). When it's compared with the results of other hospitals in other countries it was so close to ideal.

Contributors

All authors contributed to the conception or design of the work, the acquisition, analysis, or interpretation of the data. All authors were involved in drafting and commenting on the paper and have approved the final version.

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Conflict of Interest

The author has no conflict of interest.

Disclosure

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Ethical approval

Informed consent was obtained from all participants.

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