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Evaluation of Radiation doses and Radiation Risk in Teaching Sohag Hospital, Egypt

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Abstract Measurement of background ionizing radiation level at Teaching Sohag Hospital, Egypt was carried out using Thermo Scientific RadEye B20 Multi-Purpose Survey Meters. Radiation doses from MRI, CT, X-ray, US and linear accelerator departments and its related risks to the patients from were analyzed. The results indicated that the ambient dose rate and indoor annual effective dose rate (IAEDR) are high when the devise is ON. Ambient dose values ranged from 0.082±0.015 to 0.09±0.019 µSv/hr, 0.084±0.011 to 349.6±67.582 µSv/hr, 0.076±0.038 to 36.28±36.308 µSv/hr and 0.094±0.013 to 4.3±1.447 µSv/hr for MRI, CT, X-ray and linear accelerator, respectively. Results obtained range from 0.07±0.014 µSv/hr to 0.186±0.024 µSv/hr with an average of 0.1±0.023 µSv/hr for indoor measurement in different departments and locations within the hospital. This present work showed that the CT, X-ray and linear accelerator systems can impart high radiation doses and increase of radiation risk to patients if optimization protocols are ignored. The radiation doses values when compared to standard of 0.274µSv/hr recommended as worldwide average natural dose of background ionizing radiation are within permissible allowed value in different departments and locations within the hospital. Therefore, different departments in Teaching Sohag Hospital are radiologically safe.

Keywords Ambient dose equivalent, IAEDR, Radiation protection, Radiation risk, RadEye B2

1. Introduction

Ionizing radiations are part of the human environment such as cosmic rays and naturally occurring radioactive materials. They involve electromagnetic radiations (X-rays and gamma rays) as well as corpuscular radiations (alpha, beta and neutron radiations). Ionizing radiations can activate acute effects (for instance, burns) and long-term effects (for instance, cancer and hereditary diseases), which are also known as non-stochastic and stochastic effects. Radioactive sources are used through the world for a wide variety of useful purposes in industry, medicine, research, agriculture and education. The use of radioactive sources includes risks due to radiation exposure. Exposure to ionizing radiation is extensively used by physicians and health professionals in diagnosis and in the treatment of diseases [1].

Radiations in hospitals originated from three main sources, medical exposures, cosmic and terrestrial radiation and radioactivity from the background [2]. So, dose measurements are essential in every hospital to ensure compliance with acceptable reference level as well as consideration to justification and appropriate optimization.

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Medical exposures constitute a good percentage of indoor background ionising radiation [3].

The radiographies, CT and X-rays investigations can protect life but their high level radiation doses can affect people health. International Commission on Radiological Protection (ICRP) had definite that the use of computed tomography (CT) had inclined significantly and the radiation dose from CT procedures may be too high [4]. X-ray machines and radiation emitting sources are used in hospitals for the diagnosis and treatment of diseases. X-ray examinations expose the human body to variable amounts of radiation. Depending on its location with respect to the boundaries of the irradiated body volume, a specific organ or tissue can be exposed to primary radiation completely, partly, or not at all. Moreover, the long-term outcomes after endovascular repair are not as well documented as the long-term outcomes after open repair. In particular, the exact cancer and mortality risks associated with such treatments should be evaluated [5]. Linear accelerators machines used in radiation therapy for the treatment of cancer and other diseases.

Exposure of patients to radiographic examination (computerized tomography (CT), and routine exposure to x-rays), radioisotope procedures and radiation therapy have contributed to increase in background radiation and radiation levels of patients and many occupational workers [6]. As the time spent in a radiation field increases, the radiation dose received also increases. Therefore, it is best to minimize the time spent in any radiation area. As the distance from a radiation source increases, the radiation exposure decreases rapidly.

The global average natural dose of background ionizing radiation to humans is about 0.274 μSv/hr [7]. Eighty percent (80%) of which results comes from nature, while the remaining 20% results from exposure to man-made radiation sources, primarily from medical imaging. Average background ionizing radiation exposure is much higher in developed countries, mostly due to various industrial and medical activities. The International Commission on Radiological Protection (ICRP) recommends that dose limits are 20mSv/year for occupational exposure (for workers engaged in radiation work) and 1mSv/year for the general public [8].

The hospital has many departments and units which may contain radiation emitting devices and drugs. So, the current study was showed in order to assess the background ionization levels and its related risk to the occupational workers, patients and general publicto determine its radiation burden and to provide base-line data for future studies in Teaching Sohag Hospital in Egypt.

2. Material and Method

The indoor radiation level measurement of Teaching Sohag Hospital in Egypt was obtained with a hand held dosimeter: RadEye B20 from Thermo Scientific. The selected locations for the study were: MRI, CT, X-ray, US and linear accelerator departments, Cardio thoracic, surgery, General Surgery, Orthopedic, Pediatric, ENT, Obstetrics and Gynecology, Neuropsychiatry, Internal Medicine, Urology, Ophthalmology, oncology departments and In a different place in hospital. Handheld Nuclear Radiation Monitor dosimeter develops safety in laboratories and in the hospital through rapid analysis and determination of radiation levels. The handheld monitor measures alpha, beta, gamma and x-radiation. Its safety-first calibration feature can reduce exposure for personnel. The readings were measured directly (within a minute), exposure rate was taken in μSv/hr and taken four times with each and an average taken and recorded. The indoor ambient dose rate from the survey meter was converted to the indoor annual effective dose rate in for each of the location using this relation by FaraiI [9]:

IAEDR (mSv/yr) = (x) μSv/hr x 8760 hr/yr x 0.8 x 0.001 (1)

Where x is the indoor ambient dose rate in micro Sievert per hour (μSv/hr).

3. Result and Discussion

The MRI, CT, X-ray, US and linear accelerator are required to assess the radiation risks associated with the scanning examinations for patients and worker in Teaching Sohag Hospital, Egypt. The results are presented in Tables 1-2, while Figs. 1-4 show the obtained results compared with standard. Better knowledge about radiation due to exposure from patients is important for deciding on reasonable and appropriate precautions against unnecessary radiation exposure for employees and next-of-kin. Our results reaffirm that "undue anxiety among hospital staff with regard to exposure to radioactive patients must be placed in the proper perspective through education and training". However, we observed that significant anxiety was still present. Perhaps particularly amongst staff not directly involved in hospital, but still in contact with the patients in other departments.

Results are higher due to various sources of low-emitting ionizing radiation in the hospital. Moreover, radiological burden of the hospital is within the permissible value of UNSCEAR in most of departments in hospital and higher than that of CT, X-ray and linear accelerator departments. Table 1 shows ambient dose rate for MRI, CT, X-ray, US and linear accelerator departments of the hospital. The values ranged from 0.09±0.019 to 0.082±0.015 μSv/hr, 349.6±67.582 to 0.084±0.011 μSv/hr, 36.28±36.308 to 0.076±0.038 μSv/hr and 4.3±1.447 to 0.094±0.013 μSv/hr for MRI, CT, X-ray and linear accelerator, respectively. The maximum dose rate was showed at CT departments. While, the minimum does rate was obtained from the Ultra Sound (US). Inside the device (near from radiation source), from Fig. 2 the radiation dose rates are very high when the devices are operated (ON) which are349.6±67.582, 36.28±36.308 and 4.3±1.447 μSv/hr of CT, X-ray and linear accelerator, respectively. To reduction of exposure due to an increase in distance is governed by the inverse-square law. As the distance from a radiation source increases, the radiation exposure decreases rapidly.

In Control Room, the dose rates are high but reduce when the devices are operated (ON) in all case which is 0.09±0.019, 12.528±5.751, 0.15±0.034, 0.084±0.005 and 0.176±0.036 μSv/hr of MRI, CT, X-ray, US and linear accelerator, respectively. While, the dose rates are low when the devices are OFF in all case which are 0.082±0.015, 0.094±0.017, 0.094±0.011, 0.082±0.004 and 0.136±0.046 μSv/hr also in Control Room of MRI, CT, X-ray, US and linear accelerator, respectively as shown in Fig. 1. The CT scanners use x-rays and computers to produce images of the body in sections called slices. In CT, x rays are produced only when the unit is turned ON by an operator. In X-ray device, the exposure time is very short, usually less than one second, and x rays are emitted from the machine only when the control switch to the unit is turned ON by the operator. X rays and high-energy electrons are produced from the linear accelerator only when the beam is turned ON.

Table 2 shows background ionizing radiation for departments and locations within the hospital. The values ranged from 0.07±0.014 μSv/hr to 0.186±0.024 μSv/hr with a mean of 0.1±0.023 μSv/hr. The highest radiation doses were found in the pharmacy and Oncology Department. While, the lowest radiation doses were existed in Hearing and equilibrium unit as shown in Fig. 3, 4. The mean of IAEDR for all departments and different locations was (0.72±0.15) mSv/yr.

Table 1. Dose rate (μSv/hr) and indoor annual effective dose rate (IAEDR (mSv/yr)) due to some devises in different places in Teaching Sohag Hospital

Devices	Places		Dose rate (μSv/hr)	IAEDR (mSv/yr)
Magnetic Resonance Imaging (MRI)	Control Room	on	**0.09±0.019**	**0.631**
		off	0.082±0.015	0.575
	Inside the device	on	0.086±0.009	0.603
		off	0.088±0.008	0.617
	diagnostics room		0.086±0.005	0.603
	Waiting hall		0.082±0.004	0.575
	electrical room		0.088±0.008	0.617
CT	Control Room	on	12.528±5.751	87.796
		off	0.084±0.011	0.589
	Inside the device	on	**349.6±67.582**	**2449.997**
		off	0.094±0.017	0.659
	diagnostics room		0.088±0.008	0.617
	Waiting hall		0.092±0.011	0.645
X-ray	Control Room	on	0.15±0.034	1.051
		off	0.094±0.011	0.659
	Inside the device	on	**36.28±36.308**	**254.250**
		off	0.076±0.038	0.533
	diagnostics room		-	-
	Waiting hall		0.114±0.028	0.799
Ultra Sound (US)	Control Room	on	**0.084±0.005**	**0.589**
		off	0.082±0.004	0.575
	Inside the device	on	-	-
		off	-	-
	diagnostics room		-	-
	Waiting hall		-	-
Linear Accelerator (LA)	Control Room	on	0.176±0.036	1.233
		off	0.136±0.046	0.953
	Inside the device	on	**4.3±1.447**	**30.134**
		off	0.158±0.008	1.107
	diagnostics room		0.094±0.013	0.659
	Waiting hall		-	-

Table 2. Dose rate (μSv/hr) and indoor annual effective dose rate (IAEDR (mSv/yr)) at different places in Teaching Sohag Hospital

Code	Places	Dose rate (μSv/hr)	IAEDR (mSv/yr)
D1	Cardio thoracic Department	0.083±0.001	0.579328
D2	surgery Department	0.096±0.01	0.669264
D3	General Surgery Department	0.12±0.009	0.837456
D4	Orthopedic Department	0.092±0.011	0.641232
D5	Pediatric Department	0.101±0.014	0.70942523
D6	ENT Department	0.104±0.008	0.728832
D7	Obstetrics and Gynecology Department	0.101±0.012	0.7106112
D8	Neuropsychiatry Department	0.094±0.008	0.658752
D9	Internal Medicine Department	0.119±0.006	0.830448
D10	Urology Department	0.113±0.014	0.7905024
D11	Ophthalmology Department	0.118±0.006	0.826944
D12	Oncology Department	**0.129±0.027**	**0.901696**
U1	Hearing and equilibrium unit	0.07±0.014	0.49056
U2	dialysis unit	0.088±0.008	0.616704
U3	Cochlear implant unit	0.11±0.012	0.77088
U4	Analyzes tissue unit	**0.116±0.017**	**0.812928**
U5	Physiotherapy Unit	0.108±0.013	0.756864
P1	blood bank	0.094±0.015	0.658752
P2	Outpatient clinics	0.096±0.018	0.672768
P3	Internal medicine Reception	0.084±0.005	0.588672
P4	orthopedic Reception	0.084±0.005	0.588672
P5	Personnel management	0.08±0.016	0.56064
P6	Engineering management	0.106±0.009	0.742848
P7	Budget manager	0.1±0.007	0.7008
P8	Administrative and Financial manager	0.094±0.011	0.658752
P9	pharmacy	**0.186±0.024**	**1.303488**
P10	pharmacist office	0.106±0.005	0.742848

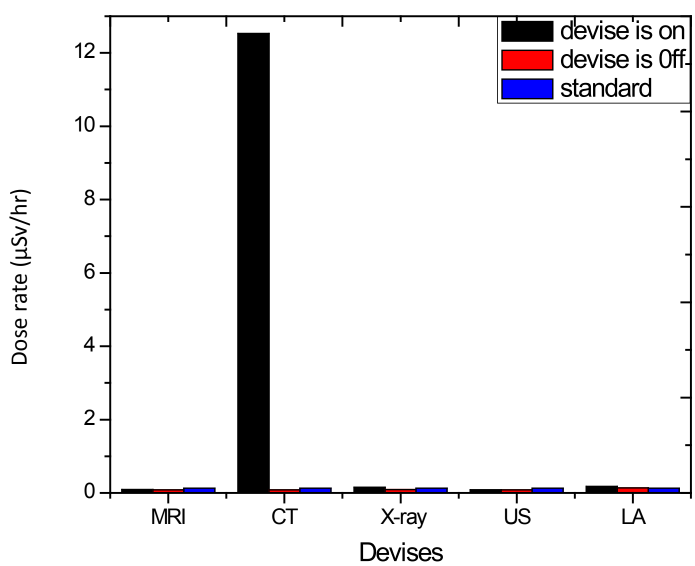

Figure 1. Dose rate due to some devices at control rooms in Teaching Sohag Hospital

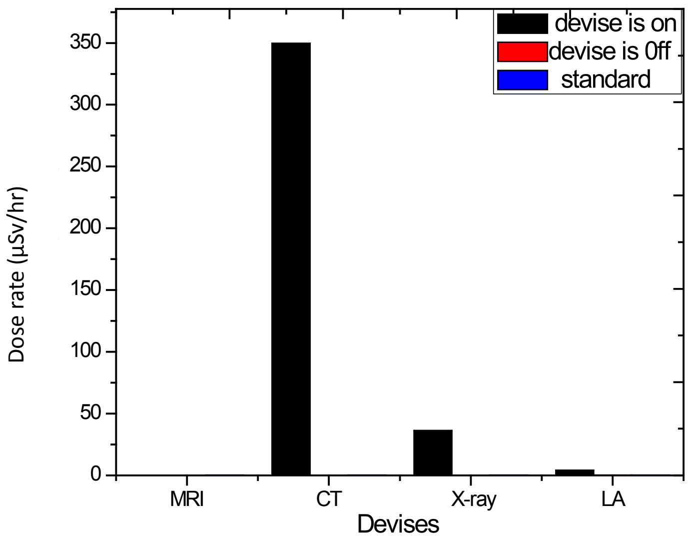

Figure 2. Dose rate due to some devices at inside them in Teaching Sohag Hospital

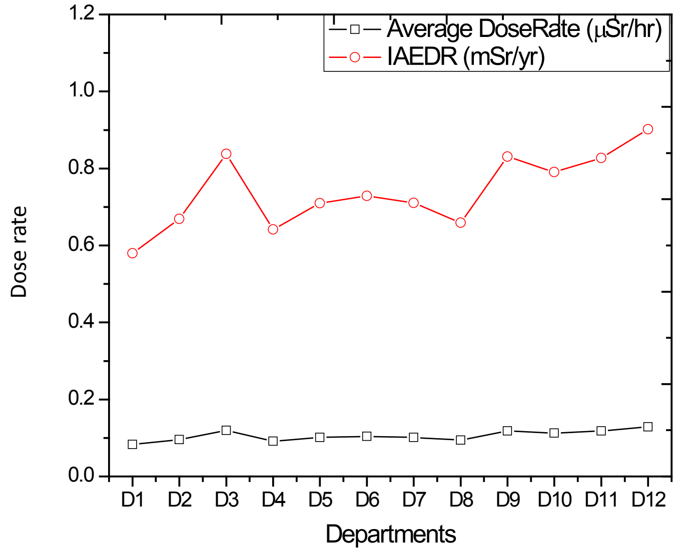

Figure 3. Average Dose rate and IAEDR in different departments of Teaching Sohag Hospital

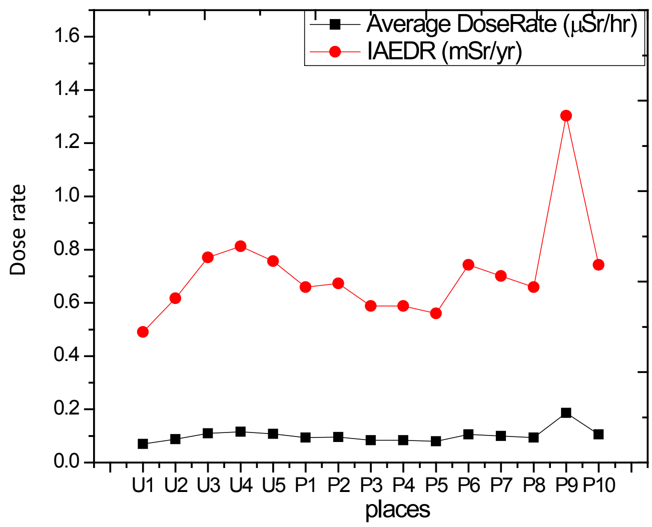

Figure 4. Average Dose rate and IAEDR in different places in Teaching Sohag Hospital

4. Conclusions

Radiation dose is a very important parameter to control the quality of the MRI, CT, X-ray, US and linear accelerator services within the hospital. Dose monitoring helps to ensure the best possible protection of the occupational workers, patients and general publicand provides an immediate indication of incorrect use of technical parameters or equipment malfunction.

Measurements of ambient dose rates for most of departments and location in Teaching Sohag Hospital in Egypt were performed using RadEye B20 dosimeter. The mean dose rate and indoor annual effective dose rate (IAEDR) have been obtained as 0.1±0.019 μSv/hr and 0.7±0.16 mSv/yr, respectively when the devices are OFF. While, the mean dose rate and IAEDR have been obtained as 0.22±1.2 μSv/hr and 1.47±8.2mSv/yr, respectively when the devices are operated (ON). This dose is assumed to correspond to workers and patients in the study area.

The results of this study indicated that there are insignificant health hazards of 1 mSv/yr equivalent dose rate for public exposure in CT, X-ray, linear accelerator and pharmacy departments and 20mSv/yr for radiation workers in CT, X-ray and linear accelerator departments. Ionizing radiation safety monitoring and assessment have become issues of great concern environments since at high doses, ionizing radiation is carcinogenic. This study provides additional data to establish reference dose level for diagnostic radiology in Egypt. The results are also useful international and professional organizations.

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