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Assessment of Radiation Dose from CT to Workers and Public from Common Diagnostic Investigations in Qatif Hospital

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Abstract: ***In general, the exposure to ionizing radiation, whether accidental, occupational or medical leads to harmful biological consequences like death or the initiation of cancer formation. The aim of the research project is to evaluate the radiation dose from computed tomography (CT) to workers and public from common diagnostic investigation in Qatif hospital. Also the annual effective doses due to diagnostic investigations will be calculated and compared with maximum permissible of the world recommended limits. And finally to create interest and increase the radiation workers and public awareness about the ionizing radiation hazard from CT particularly due to repeated scans. In this work the measured annual absorbed dose of 8.01±0.51mSv and 3.07±0.15mSv at the control area was found to be received by operators working in Qatif central hospital (Phillips ICT-128 slices) and Qatif central hospital (Somatom Definition AS-64 slices) respectively. The public in these hospital was found to expose to annual doses of 2.29±0.09mSv and 1.41±0.09mSv from Qatif central hospital (Somatom Definition AS-64 slices), and Qatif central hospital (Phillips ICT-128 slices) respectively. Although there are some slightly differences in our measurements in comparison of these hospital, all the findings are within the allowable recommended limits of annual absorbed dose from the ionizing radiation by the international cooperation of radiation protection (ICRP).***

Keywords: Ionizing radiation, Computed tomography (CT)

1. Introduction

Ionizing radiation represents electromagnetic waves and particles that can ionize and remove an electron from an atom or molecule of the medium through which they propagate. Ionizing radiation may be emitted in the process of natural decay of some unstable nuclei or following excitation of atoms and their nuclei in nuclear reactors, cyclotrons, x-ray machines or other instruments. For historical reasons, the photon (electromagnetic) component of ionizing radiation emitted by the excited nucleus is termed gamma rays and that emitted from machines is termed x rays. The charged particles emitted from the nucleus are referred to as alpha particles (helium nuclei) and beta particles (electrons) [1].

Ionizing radiation (IR) is known as a classical mutagen capable of inducing various kinds of stable and unstable chromosomal aberrations (CA) including the possibility of increasing the incidence of DNA damage [2]. It is well known that ionizing radiation induce DNA double strand break (DSB) [3]. Most of DSBs repair rapidly and accurately [4]. A small number of breaks remain unrepaired and become visible in subsequent metaphase chromosomes. Several studies performed using cytogenetic analysis, report the presence of increased frequencies of chromosomal aberrations in peripheral blood lymphocytes of individuals accidentally, environmentally or occupationally exposed to cumulative low level of ionizing radiation [5-6]. However, the relationship between ionizing radiation exposure level and the elevation of the frequencies of different types of structural chromosomal aberrations is not yet completely clarified [7]. Chromosomal abnormalities have been correlated with genetic alterations that can trigger genomic instability and development of cancer. Therefore a bio monitoring based on chromosome aberration analysis make it possible to estimate the cancer risk [8]. In order to prevent the occurrence of significant changes in the genetic pool of the whole population, it is very important to monitor hospital workers chronically exposed to radiation for many years. Moreover, recent technological advances have greatly expanded the new modalities for use of ionizing radiation in diagnostic and treatment. For example, interventional radiology such as cardiac catheterization constitutes a source of relatively high exposure [1]. Extensive use of multi-slice computed tomography has also increased radiation doses [9]. International commission on radiological protection reported that the organ dose from CT-scan can often approach or exceed that observed in atomic bomb survivors [10].

Exposure to ionizing radiations (IR), whether accidental, occupational or medical, leads to harmful biological consequences like death or carcinogenesis. High doses of IR are clearly known to induce acute and chronic effects in humans, while the potential risk for detrimental effects associated with low doses of radiation is still a matter of debate [11]. Based on the United Nations Scientific Committee on the Effects of Atomic Radiation [1] reports, amongst all workers exposed worldwide to man-made sources of radiation, medical radiation workers represent the largest group as they are most consistently exposed to low doses of IR. Ionizing radiation is used daily in hospitals and clinics to perform diagnostic imaging procedures like X-rays, CT-scan, bone scan, mammogram, PET and its sources may be found in a wide range of occupational settings .There was an increasing interest in biological markers for low level chronic radiation exposure observed amongst radiation workers [12]. There are indications from epidemiological studies that medical radiation workers, in particular those from the earliest cohorts with substantial accumulated doses, may show an increase in cancer mortality [13].

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The Ionizing Radiations Regulations 1999 (IRR99), 1 made under the Health and Safety at Work etc. Act 1974 (HSW Act), 2 implement the majority of the Basic Safety Standards Directive 96/29/Euratom3 (BSS Directive) in Great Britain (Northern Ireland publishes separate regulations). From 1 January 2000, they replace the ionizing Radiations Regulations 1985 (IRR85) (except for regulation 26 (special hazard assessments)) which were made in response to the 1980 BSS Directive 80/836/Euratom (as amended by 84/467/Euratom). The main aim of the Regulations and the supporting Approved Code of Practice (ACOP) is to establish a framework for ensuring that exposure to ionizing radiation arising from work activities, whether from man-made or natural radiation and from external radiation (e.g. X-ray set) or internal radiation (e.g. inhalation of a radioactive substance), is kept as low as reasonably practicable and does not exceed dose limits specified for individuals [14].

Computed tomography, or CAT scans, that produce cross-sectional images of the body using X-rays and a computer. CT scans are also referred to as computerized axial tomography. CT was developed independently by a British engineer named Sir Godfrey Hounsfield and Dr. Alan Cormack. It has become a mainstay for diagnosing medical diseases. For their work, Hounsfield and Cormack were jointly awarded the Nobel Prize in 1979[15].

CT scanners first began to be installed in 1974. CT scanners have vastly improved patient comfort because a scan can be done quickly. Improvements have led to higher-resolution images, which assist the doctor in making a diagnosis. For example, the CT scan can help doctors to visualize small nodules or tumors, which they cannot see with a plain film X-ray [15].

Globally, CT scanning represents a contribution of just over 44% to the global collective effective dose equivalent from medical exposures [16]. Extrapolating from the latest UNSCEAR 2008 report there are 221 million CT examinations performed annually worldwide and 62 million of them were carried out in the US in 2006, according to the NCRP report [17].

2. Material and Method

The Data was processed by Microsoft Office Excel version 2010. We used the software for data entry: readings of the scatter radiation for the head, abdomen pelvis and chest procedures, time, kV, mAs, number of slices, background radiation, computed tomography dose index (CTDIvol) and dose length product (DLP). Also, we used the software to calculate: (the average for each procedure, the average for all procedures, standard deviation for each procedure, standard deviation for all procedures, standard error and the calculated annual dose).

The results of scattered radiation from selected diagnostic investigations (head, abdomen pelvis and chest) that expected to produce high scattered radiation was shown on tables [1, 2, 3, and 4] below and The annual effective dose due to these diagnostic investigations was shown on tables [5 and 6] and represent the calculated annual doses that received by the worker at control areas and the member of public around the CT scan rooms.

3. Results

In this work the measured annual absorbed dose of 8.01±0.51mSv and 3.07±0.15mSv at the control area was found to be received by operators working in Qatif central hospital (Phillips ICT-128 slices) and Qatif central hospital (Somatom Definition AS-64 slices) respectively. The public in these hospital was found to expose to annual doses of 2.29±0.09mSv and 1.41±0.09mSv from Qatif central hospital (Somatom Definition AS-64 slices), and Qatif central hospital (Phillips ICT-128 slices) respectively.

Table 1: Shows diagnostic investigations of head, abdomen pelvis and chest in control area

Control Area	Mean (µSv/h)			Standard Deviation		
	Head	Abdomen Pelvis	Chest	Head	Abdomen Pelvis	Chest
Qatif Central Hospital (Somatom Definition AS - 64 slice)	0.99	1.55	2.08	0.33	0.08	0.15
Qatif Central Hospital (Phillips ICT - 128 slice)	1.95	5.85	4.23	0.39	0.77	0.63

Table 2: Shows diagnostic investigations of head, abdomen pelvis and chest out of the wall

Wall	Mean (µSv/h)			Standard Deviation		
	Head	Abdomen Pelvis	Chest	Head	Abdomen Pelvis	Chest
Qatif Central Hospital (Somatom Definition AS - 64 slice)	1.36	0.98	1.1	0.23	0.20	0.43
Qatif Central Hospital (Phillips ICT - 128 slice)	1.08	0.47	0.58	0.08	0.10	0.18

Table 3: Show the calculated mean, standard deviation and the standard error of all examinations in the control area

Control Area	Mean for all Exams (µSv/h)	Std. deviation for all exams	Std. error for all exams
Qatif Central Hospital (Somatom Definition AS - 64 slice)	1.54	0.50	0.15
Qatif Central Hospital (Phillips ICT - 128 slice)	4.01	1.76	0.51

Table 4: Show the calculated mean, standard deviation and the standard error of all examinations in the wall

Wall	Mean for all Exams (µSv/h)	Std. deviation for all exams	Std. error for all exams
Qatif Central Hospital (Somatom Definition AS - 64 slice)	1.15	0.32	0.09
Qatif Central Hospital (Phillips ICT - 128 slice)	0.71	0.30	0.09

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Table 5: Show the staff calculated annual dose for the four hospitals.

Control Area	Annual Dose (mSv/y) ± Standard error
Qatif Central Hospital (Somatom Definition AS - 64 slice)	3.07 ± 0.15
Qatif Central Hospital (Phillips ICT - 128 slice)	8.01 ± 0.51

Table 6: Show the calculated public annual dose for the five hospitals.

Wall	Annual Dose (mSv/y) ± Standard error
Qatif Central Hospital (Somatom Definition AS - 64 slice)	2.29 ± 0.08
Qatif Central Hospital (Phillips ICT - 128 slice)	1.41 ± 0.09

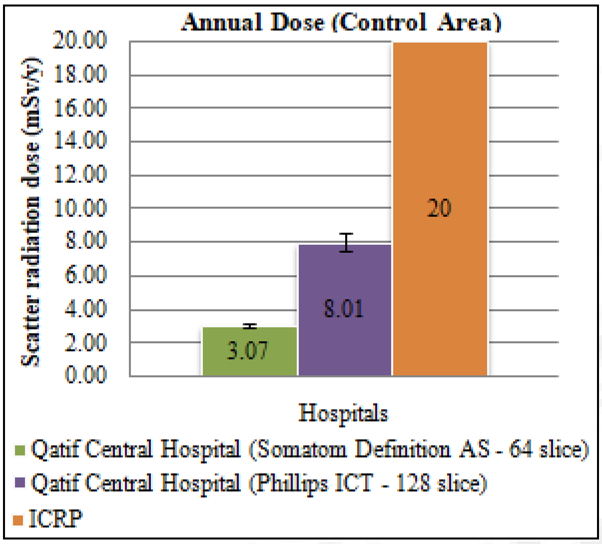

Figure 1: Show the calculated annual doses measured in control area in five different CT scanners rooms for an employee works eight hours a day, five days a week in the whole year.

Annual Dose = mean for all measurements × 8hours × 5days × 50week

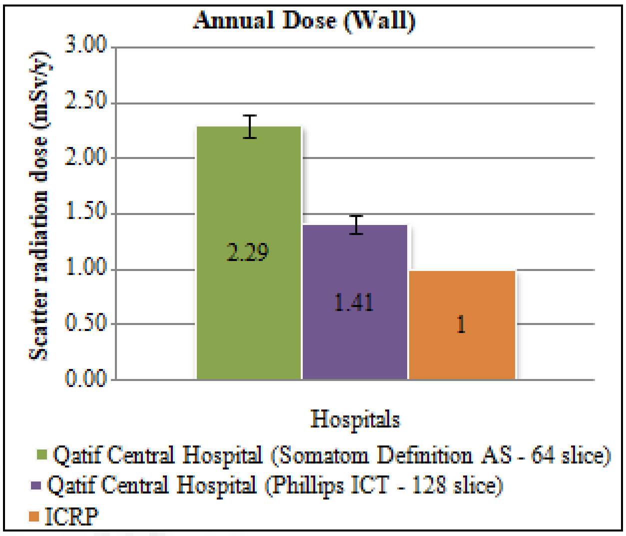

Figure 2: Show the calculated annual doses measured in a wall in five different CT scanners rooms for members of public around CT scan rooms works eight hours a day, five days a week in the whole year.

Annual Dose = mean for all measurements × 8hours × 5days × 50week

Table 7: Show readings measured in the Qatif Central Hospital by Somatom Definition AS 64 slice CT scanner

Parameters		Reading (µSv/h)	Time (sec)	kV	mAs	No of Slices	Background (nSv/h)	CTDIvol (mGy)	DLP (mGycm)
Control Area	Head	1.36	8.67	120	382	48	1	58.91	904.7
		0.7	7.89	120	370	46	3	59	865.5
		0.72	7.16	120	370	52	3	60.50	983.3
		1.16	8.32	120	330	35	2	59.57	924.4
	Abdomen Pelvis	1.44	5	120	153	152	2	11.68	489.7
		1.61	5.86	120	159	175	3	12.54	486.2
		1.61	4.94	120	270	175	3	12.67	602.3
		1.52	5.42	120	240	168	2	11.51	520.1
	Chest	2.15	8.91	120	273	145	2	8.61	482
		2.21	9.56	120	220	141	3	8.39	467.4
		1.87	9.61	120	110	137	3	8.38	357.7
		2.08	8.8	120	140	131	3	8.47	423.6
Wall	Head	1.7	8.67	120	382	48	1	58.91	904.7
		1.28	7.89	120	370	46	3	59	865.5
		1.24	7.16	120	370	52	3	60.50	983.3
		1.22	8.32	120	330	35	2	59.57	924.4
	Abdomen Pelvis	0.78	5	120	153	152	2	11.68	489.7
		1.01	5.86	120	159	175	3	12.54	486.2
		1.25	4.94	120	270	175	3	12.67	602.3
		0.89	5.42	120	240	168	2	11.51	520.1
	Chest	1.17	8.91	120	273	145	2	8.61	482
		1.58	9.56	120	220	141	3	8.39	467.4
		0.54	9.61	120	110	137	3	8.38	357.7
		1.1	8.8	120	140	131	3	8.47	423.6

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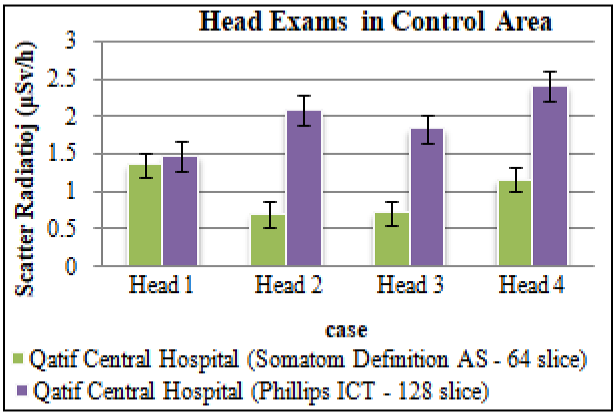

Figure 3: Show the distribution of readings from the dosimeter for head sequences for adult patients measured in five different CT scanners rooms. The measurements are taken in contact with the window in the control area.

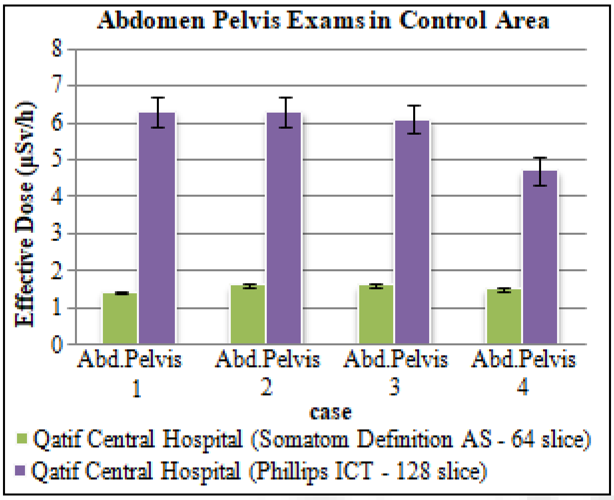

Figure 4: Show the distribution of readings from the dosimeter for abdomen pelvis for adult patients measured in five different CT scanners rooms. The measurements are taken in contact with the window in the control area.

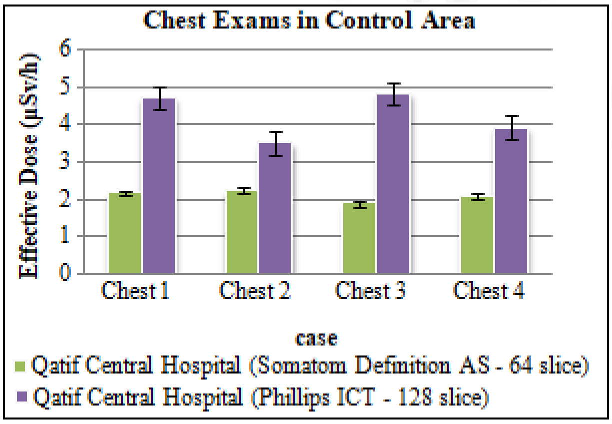

Figure 5: Show the distribution of readings from the dosimeter for chest sequences for adult patients measured in five different CT scanners rooms. The measurements are taken in contact with the window in the control area.

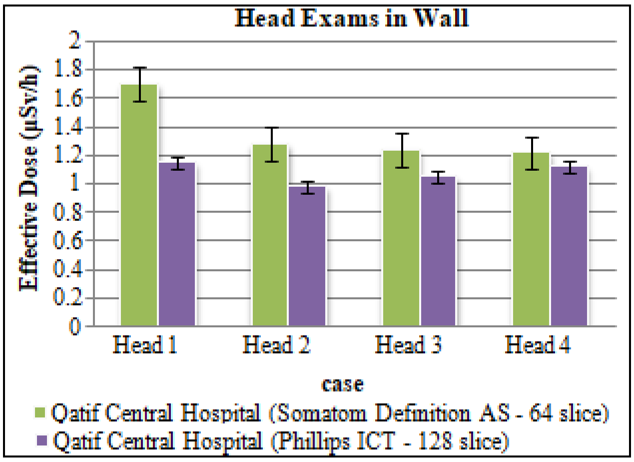

Figure 6:. Show the distribution of readings from the dosimeter for head sequences for adult patients measured in five different CT scanners rooms. The measurements are taken in contact with a wall next to the control area.

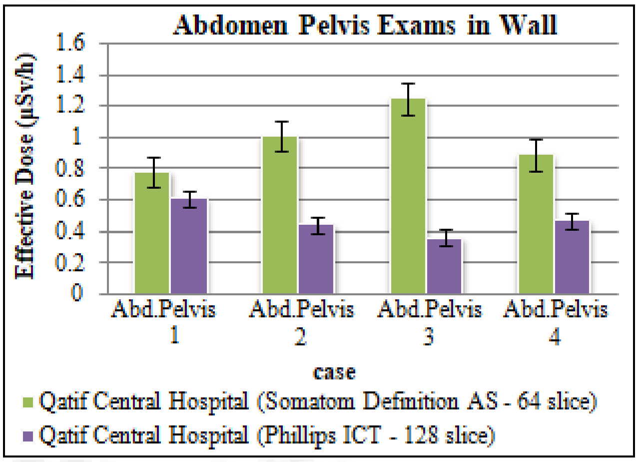

Figure 7: Show the distribution of readings from the dosimeter for abdomen pelvis for adult patients measured in five different CT scanners rooms. The measurements are taken in contact with a wall next to the control area.

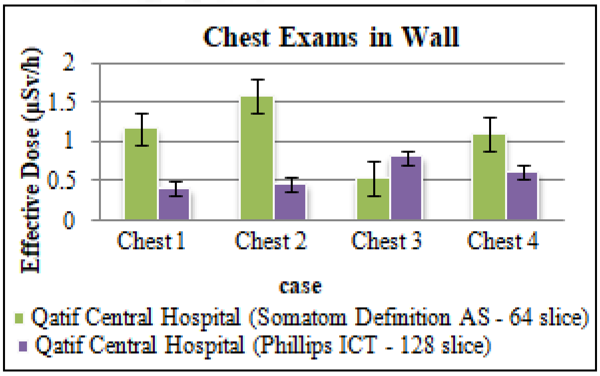

Figure 8: Show the distribution of readings from the dosimeter for chest sequences for adult patients measured in five different CT scanners rooms. The measurements are taken in contact with a wall next to the control area.

4. Conclusion and Recommendations

Exposure to ionizing radiation, whether accidental, occupational or medical leads to harmful biological consequences. And the medical radiation workers are the most consistently exposed to low doses of ionizing radiation.

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The experiment about raise the awareness about the hazard of ionization radiation in CT particularly due to repeated scans and scatter radiation that effect medical staff and the public. The annual dose of the staff of all hospitals within ICRP. And the annual dose for the public within the normal limits of the new regulation ICRP 103 (2007) ,but exceeded the ICRP 60 but Here are a steps we are recommending, they are not new indeed, many facilities are already taking measures to Protect Children and other small patients from unnecessary exposure during CT procedures.

a) Use ALARP (as low as reasonably practicable principle to Optimize CT parameters and balancing between image quality and radiation exposure, so no need to repeat
b) Increase the thickness of the lead and glass shielding. The more thickness of shielding will increase the more absorbing will be and less radiation will penetrate the shield.
c) Increase the size CT scan room. That will increase the distance between X-raw source and the shield. Energy per unit of area perpendicular to the source is inversely proportional to the square of the distance from the source (Inverse-square law).
d) Choosing the best diagnostic modality. Don't use CT scan unless it's necessary.
e) Periodic measure of scatter radiation to maintaining on safe work environment.

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