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Towards the Establishment of National Diagnostic Reference Levels (DRLs) in Palestine: Assessment of the Diagnostic Reference Levels for CT adult patients in the Non-Governmental (NGOs) Medical Centers in the West Bank-Palestine

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Abstract

Computed Tomography(CT) is one of the most ionizing radiation technique used in diagnostic radiology. The radiation protection against the ionizing radiation play an essential role for patient protection, the radiation dose in CT described by CTDIvol and DLP. This study aims to assess the average doses, i.e. dose descriptors (CTDIvol and DLP) in the Palestinian NGO imaging facilities, for the most common adult computed tomography (CT) routine examinations. The study implemented a quantitative research method carried out to a representative sample, in which all the available data was taken from exams including (CTDIvol, DLP, and other acquisition parameters). This study was carried out in all routine examinations (Brain, Chest, Abdominopelvic, and Lumbar spine examinations), which were performed in the Palestine NGO imaging facilities, over a period of three months.

The Study results conclude that the average doses from the private and NGOs CT imaging facilities were generally within the ranges of the averages from the different countries used as reference in this study, In this study it was found that the averages of (CTDIvol) for Brain, chest, Abdominopelvic and Lumber spine CT-scans, were (51.77±14.53mGy), (12.82±3.19mGy), (23.39±13.59mGy) and (25.31±9.22mGy) respectively, while DLP were (1069.47±369.32mGy.cm), (510.30±237.75mGy.cm), (1070.66±692.74mGy.cm), (682.69±247.96mGy.cm) for the same examinations.

Keywords: CTDIvol, DLP, CT, MSCT, ICRP, ALARA, NGO, kVp, mAs, dose

1. Introduction

Computed Tomography (CT) is a radiographic procedure is produces a three dimensional (3D) image of the human organs; it has revolutionized diagnostic radiology especially with the modern high speed multi-detector CT technologies to reduce the scan time [1,2].

CT is one of the ionizing radiation procedures which has a risky to the person who deals with the dose in CT varies from patient to patient. It depends on the coverage body size during the examination, and the type of the CT device such as multi-detectors and dual energy CT. Though the risk of the radiation is very small in possibility, but it may be associate with some symptoms such as cancer [3,4], dizziness, headache, and other. Thus the estimation of radiation dose plays a key role for patient protection. [5,6,7,8].

There are several measurements used in CT to describe the radiation dose such as absorbed dose, effective dose, CT dose index (or CTDI), and Dose-length product (DLP) [9,10]. The absorbed dose is used to describe the absorbed energy per mass unit , and it measured in gray (Gy). It is used to estimate the risk factor of the organ dose [11,12]. The effective dose is defined as the radiation dose which is distributed onto non-homogeneous tissues; It estimates the overall harm caused by radiation dose, and it is expressed in Sieverts (Sv) [13,14].

Volume CT dose index (CTDIvol) is considered one of the dose units used in CT; it is an international unit that is an essential measurement of the radiation output from the CT equipment [15,16,17]. Dose-length product (DLP) is another unit used to know the patient dose under the CT examination; it is calculated by multiplied CTDIvol with the unit of distance of coverage; it uses milliGray (mGy).cm as a SI unit [18].The CT dose is calculated from multiple scans; it estimated by measurements from the centric slice and the several periphery points by using phantom; the total calculated dose called multiple scan average dose (MSAD), this measurement would increase with the overlap slices and less slice gaps [19,20].

Many organizations around the world provide guidelines for the CT scan monitoring examinations such as ICRP [5,21], American college of radiology, and the health protection agency in the UK [22,15].

The purpose of this study is to assess the average doses at the Palestine NGO image facilities by examinations (Brain, Chest, Abdominopelvic and lumbar spine) determine their variations from international doses aimed at the revealing of any improper dose level usage. For the application of radiation protection (ALARA) principle in our medical centers and hospital, and to investigate the average doses inside the NGO Palestinian hospitals and compare it with international average doses.

2. Materials and Methods

2.1.Study Design and Setting

This retrospective cohort study was performed at West Bank private and NGOs hospitals and medical centers. It was conducted to describe the CT dose. The assessment of the CT dose descriptors (CTDI) and (DLP) at the west bank region Palestine NGO that have CT scanners. Table 1 shows the names and abbreviations of the 20 image facilities that have CT scanners in 7 cities in west bank. The CT dose descriptors collected from the most common CT examinations performed. This study was conducted over the period of 3 months from 1 September to 1 December 2017.

NO	Facility name	Abbreviation
1	Palestine Radiology Center/ Hebron	PRCH
2	Shahin Radiology Center/Hebron	SRCH
3	Al-Mizan Hospital/ Hebron	MHH
4	Palestinian Red Crescent Hospital Hebron	PRCHH
5	Al-Ahli Hospital/ Hebron	AHH
6	Shifa Medical Center/Bethlehem	SMCB
7	Al-Yamama Hospital/ Bethlehem	YHB
8	Bethlehem Arab Society For Rehabilitation/ Bethlehem	BASR
9	St. Joseph Hospital/Jerusalem	StJHJ
10	Makassed Islamic Charitable Society Hospital/Jerusalem	MICSHJ
11	Istishari Hospital/Ramallah	IHR
12	Arab Care Hospital / Ramallah	ACHR
13	Palestinian red crescent hospital/Ramallah	PRCHR
14	Arabic specialist Hospital/Nablus	ASHN
15	Al-Rahma Medical Center/Nablus	RMCN
16	An-Najah National University Hospital/Nablus	NNUHN
17	ST.Luke's Hospital/Nablus	STLHN
18	Nablus specialist Hospital/Nablus	NSHN
19	Al-zakah Hospital/Tulkarim	ZHT
20	Al-Razi Hospital/Jenin	RHJ

Table (1): The names and abbreviations of the 20 image facilities that contain CT scanners in 7 cities in west bank.

The study focused on all routine adult CT examinations including brain, chest, Abdominopelvic, and Lumbar spine in all the hospitals over a three-months period. The sample was conducted to collect all the available data (CT examinations) from the CT operator consoles, in which a Convenience sampling design was used. This means that the researchers collected all the examinations saved on the computer system by the medical imaging team, after the patient was examined in these imaging facilities.

The NGO centers that did not have CT scanners were excluded. The patients under the age group of 18 years also were not included in the study. Some data was to be shown but some CT scanners were not functioning properly.

2.2.Data collection

To facilitate planning of the national dose survey, CT scanners that exist in the NGO image facilities in the west bank and clinical centers were studied certain criteria were taken into account in our examination of these facilities: manufacturer, scanning technology, and number of slides (Table 2). The Data were tabulated in an Excel sheet designed previously including scan parameters (tube voltage (kVp), (mAs)), and dose descriptors (CTDI&DLP).

NO	Hospital name	CT scanner (manufacturer)	Number of slices	scanning technology
1	PRCH	Philips	**16**	Helical
2	SRCH	Simens	**2**	Helical
3	MHH	Philips	**16**	Helical
4	PRCHH	Philips	**128**	Helical
5	AHH	Simens/GE	**32/256**	Helical
6	SMCB	Philips	**64**	Helical
7	YHB	Philips	**16**	Helical
8	BASR*	-------	**------**	Helical
9	StJHJ	Philips	**64**	Helical

10	MICSHJ	**	**------**	Helical
11	IHR	Philips	**256**	Helical
12	ACHR	Philips	**16**	Helical
13	PRCHR**	--------	**-------**	Helical
14	ASHN	Philips	**16**	Helical
15	RMCN	Philips	**128**	Helical
16	NNUHN	Simens	**128**	Helical
17	STLHN**	-------	**------**	Helical
18	NSHN	GE	**16**	Helical
19	ZHT	Philips	**4**	Helical
20	RHJ	Philips	**128**	Helical

Table (2): The characteristics of the CT scanners that present in West Bank NGO imaging facilities.

* BASR refused to cooperate with the researchers, data was not collected

*** PRCH-B and STLHN was not functioning properly, data was not collected.

2.3.Data Analysis

The data were analyzed using an Excel sheet form in which the average and standard deviation of the dose descriptors (CTDI) and (DLP) counting of CT examinations and the other acquisition parameters were counted. The tables that represent the variations of dose descriptors were compared with other countries and between Palestinian NGO imaging facilities to pinpoint their differences.

3. Results

3.1 Count of CT examinations

3.2 A question Parameters.

For this survey, about (3052) CT-examinations were collected. In reference to the type of examination, 44.5% (n=1357) of the total number is Brain CT, 22.14% (n=678) is Lumbar spine, 23.76% (n=722) is Abdominopelvic, and 9.6% (n=678) is Chest CT examination. Table.3 shows the specific numbers and their percentages of the CT examinations that are processed.

Table (3): Arrangement and account of CT examinations according to the data available and type of CT examination

Examination	**Brain**		**Abdominopelvic**		**Chest**		**Lumber spine**		**Total**	
	Freq	***%***	***Freq***	***%***	***Freq***	***%***	***Freq***	***%***	***Freq***	***%***
PRCH	21	0.68%	16	0.52%	3	0.09%	7	0.22%	47	1.51%
SRCH	28	1%	4	0.13%	4	0.13%	10	0.32%	46	1.58%
MHH	92	3.01%	15	0.50%	9	0.29%	8	0.26%	124	4.06%
PRCHH	38	1.24%	22	0.72%	12	0.39%	31	1.01%	103	3.36%
AHH	67	2.2%	27	0.88%	14	0.45%	13	0.42%	121	3.95%
SMCB	13	0.42%	12	0.40%	8	0.26%	18	0.58%	51	1.66%
YHB	30	1%	5	0.16%	4	0.13%	3	0.10%	87	1.39%
StJHJ	368	12.05%	173	5.66%	84	2.75%	183	5.99%	808	26.45%
MICSHJ	420	13.76%	333	11%	36	1.17%	273	8.94%	1062	34.87%
IHR	1	0.03%	1	0.03%	1	0.03%	1	0.03%	4	0.12%
ACHR	41	1.34%	22	0.72%	21	0.68%	40	1.31%	124	4.05%
ASHN	101	3.30%	51	1.70%	59	1.93%	20	0.65%	231	7.58%
RMCN	83	2.71%	13	0.42%	19	0.62%	47	1.53%	162	5.28%
NNUHN	5	0.16%	5	0.16%	5	0.16%	**	**	15	0.48%
NSHN	24	0.78%	9	0.30%	9	0.30%	8	0.26%	50	1.64%
ZHT	13	0.42%	5	0.16%	**	**	5	0.16%	26	0.74%
RHJ	12	0.4%	9	0.30%	7	0.22%	11	0.36%	39	1.28%
Total	**1357**	**44.50%**	**722**	**23.76%**	**295**	**9.60%**	**678**	**22.14%**	**3052**	**100%**

In the 17 out of 20 functional imaging facilities surveyed, helical acquisition geometry technology was used, and the average of each acquisition parameter was taken (Table 4). Different tube voltage (kVp) values were observed at the abdominopelvic and lumbar examinations. The maximum average of tube current (mAs) was recorded for the Lumbar CT-scans (416), with highly variable acquisition parameters.

Examination	kVp		mAs		Scan length(mm)	
	Range	*Average*	*Range*	*Average*	*Range*	*Average*
Brain	120	-	490-120	305	617-123	**370**
Abdomen	140-120	130	540-103	321.5	697-242	**469.5**
Chest	140-120	130	357-100	228.5	568.5-118	**343.25**
Lumber spine	140-120	130	707-125	416	504-146	**325**

Table (4): The mean or average and (range) of the acquisition parameters that used for four commonest CT-examinations in West Bank-Palestine imaging facilities

3.3 Dose average (dose descriptors) for the most Common four CT-examinations

The average of CT dose descriptors (CTDIvol, and DLP) was calculated, for the targeted facilities in the study to estimate the doses. The highest (CTDIvol) and (DLP) averages were detected on the brain CT examinations, and the least for the chest examinations (Table 5).

Examination	CTDIvol (mGy)		DLP(mGy.cm)	
	Average	*SD*	*Average*	*SD*
Brain	51.77	14.53	1069.47	369.32
Chest	12.82	3.19	510.30	237.75
Abd-Pelvis	23.39	13.59	1070.66	692.74
Lumbar Spine	25.31	9.22	682.69	247.96

Table (5): Dose average (dose descriptors) for the most Common four CT-examinations at West Bank- Palestine imaging facilities

Regarding the imaging facilities, table (6) shows the distribution of the examinations among the CT units in the different hospitals. It also shows the percentages of examination

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types carried out in the local facilities when compared to the percentages of the examinations carried with other countries.

Examination	West Bank(NGO)		Australia[23]		France[24]		Japan[25]		Syria[26]		Kenya[27]		Iran[28]	
	CTDI	***DLP***	***CTDI***	***DLP***	***CTDI***	***DLP***	***CTDI***	***DLP***	***CTDI***	***DLP***	***CTDI***	***DLP***	***CTDI***	***DLP***
Brain	51.77	1069.47	60	1000	65	1050	85	1350	60.7	793	61	1612	43	700
Chest	12.82	510.30	15	450	15	475	15	550	22	520	19	895	10	330
Abd-Pelvic	23.39	1070.66	15	700	17	800	20	1000	24.1	721	*/	*/	10	750
Lumbar	25.31	682.69	40	900	45	700	*	*	*	*	20	712	*/	*/

Table (6): Average doses (dose descriptors) in CT imaging at west bank-Palestine imaging facilities compared with other averages include (Australia, France, Japan, and Syria, Kenya and Iran respectively

*The countries that did not establish an averages of Lumbar spine, Abd-pelvis and chest examinations

Note: The Unit of CTDIvol is mGy, Unit of DLP is mGy*cm

3.4 Averaged CT dose descriptors, (CTDIvol and DLP) Compared with other Countries averages:

Results showed that the radiation doses delivered to patients in the CT units among the NGO are within the range of that amounts from regional and international countries (Table 7).

Hospital	Brain		Abdomen		Chest	Lumber spine		
	CTDI	*DLP*	*CTDI*	*DLP*	*CTDI*	*DLP*	*CTDI*	*DLP*
PRCH	45.4	723.15	13.3	592.9	13.3	432.69	31.4	848.69
SRCH	27.28	419.89	5.15	236.25	6.5	220	12.519	289.5
MHH	49.9	838.2	13.3	626.4	13.3	486.4	26.2	678.1
PRCHH	44.46	975.68	34.8	1800.4	20.62	924.29	20.94	973.04
AHH	80.5	1558.5	26.52	1330	17.26	587.39	27.8	1175.9
SMCB	74.4	1440	44.6	2527	32.1	1037.6	31.7	1175
YHB	49.9	897.95	16.7	1007.3	13.9	551.25	26.2	1082.8
StJHJ	38.7	890.4	17.9	1049.7	8.26	397.2	21.7	804.06
MICSHJ	45.43	1055.39	16.4	894.9	17.7	710	23.6	766
IHR	51.7	1121.6	51	1126	12	445	8.2	223.5
ACHR	61.24	1565.79	40.63	2200.74	7.95	316.12	35.4	1357.71
ASHN	75.03	1847.43	36.92	2011.15	19,94	757	43.05	1289.23
RMCN	57.94	1320	12.2	691.27	9.67	561.06	21.13	843.25
NNUHN	42.8	752	16.36	903	6.38	206.4	--	--
NSHN	49.4	778.7	8.84	403.59	8.99	278.09	13.18	456.13
ZHT	32.5	880.69	15.6	645.2	---	---	36.2	644.34
RHJ	53.59	1115.7	27.42	155.43	14.07	527	25.84	947.6
SD	14.53	369.32	13.59	692.74	3.19	237.75	9.22	247.96
AVG	51.77	1069.47	23.39	1070.66	12.82	510.30	25.31	682.69

Table (7): Averages (Means) of CT dose descriptors (CTDIvol) and (DLP) for each group of CT-scan examinations at West Bank- Palestine imaging facilities.

4. Discussion

The Results showed variations in the number of the performed CT examinations, according to the imaging facility examination storage for each individual examination. As observed, 44.5%of the total number were for the Brain, 23.76% for the Abdominopelvic, 9.6% for the chest and 22.14% for the Lumber spine CT. This is a normal percentage in the medical imaging departments as observed in the selected countries in this study.

Other differences were found in the acquisition parameters (kVp), (mAs), and (scanning length). These variations refer to the CT technologist selection or to the scanning protocol. In this study, the variations in tube voltage (kVp) in the Abdominopelvic, Lumbar spine and chest was averaged to (130±10) kVp, while the Brain examinations tube voltage is invariable to 120 kVp in all imaging facilities. Moreover, other differences that show an increasing in tube current (mAs) averages. These values have shown an increase in the (mAs) used for the lumber spine (=416±300) since this need a higher radiation in order to obtain a good resolution. However, the average minimum value of the range for the chest was (228.5±128.5). The Abdominopelvic was (321.5±218.5), while the average in Brain examinations was (305±185).

In this study it was found that the averages of (CTDIvol) for Brain, chest, Abdominopelvic and Lumber spine CT-scans, were (51.77±14.53mGy), (12.82±3.19mGy), (23.39±13.59mGy) and (25.31±9.22mGy) respectively, while (DLP) were (1069.47±369.32mGy.cm), (510.30±237.75mGy.cm), (1070.66±692.74 mGy.cm), (682.69±247.96mGy.cm) for the same examinations.

In a nutshell, the averages doses for Brain CT from the private and NGOs in the West Bank were (=51.77) generally lower than the averages from the other countries examined in this study except the averages from Iran which were about 17% less than West Bank (Avg=43). On the hand, DLP averages were generally high (Avg=1069) but also lower than Kenya by 33% (Avg=1612). This is due to the use of the wide scan lengths for some individual examinations.

The average doses for Chest CT from the private and NGOs in the West Bank were (=12.82) generally lower than the averages from the other countries examined in this study except the averages from Iran which was about 22% less than the West Bank (Avg=10) due to the use of wide scan lengths.

The average doses for Abdominopelvic CT from the private and NGOs in the West Bank were (=23.39) generally higher than the averages from the other examined countries in this study due to the use of wide scan lengths in most of the examinations and non-appropriate exposure factors, whereas (DLP) was higher (=1070.66) than other countries.

The average doses for Lumber spine CT from the private and NGOs in the West Bank were (=25.31) generally lower than the averages from the other countries in this study except the averages from Kenya which were about 21% less than the West Bank (Avg=20). This indicates the use appropriate technical exposure particularly (mAs) values, the (DLP) averages were (=682.69) the least than the others. This refers to the use of appropriate scan lengths for some of the individual examinations, especially in RMCN.

In order to detect the reason for these averages a comparison among the Palestine NGO imaging facilities themselves were compared. It was observed that the highest (CTDIvol) averages at AHH (=80.5) were for the Brain examinations with minimal variations due to the use of high exposure factors (mAs), whereas the mean for ASHN was (=490), possibly due to the of use high exposure factors (mAs), while for NSHN the use the lower tube current (mAs) the mean of was (=327.5), led to high variations in the (CTDIvol) averages for Brain. Examinations at Palestine NGO imaging facilities. Therefore, the (DLP) averages record the highest value at ASHN (=1847.43) and the least one at SRCH (=419.89) affected by the (CTDIvol).

In the Chest examination, the averages of (CTDIvol) were the highest at SMCB (=32.1). This is ascribed to the use of high tube current (mAs) with a mean of (=335), while the least (CTDIvol) averages were at SRCH (=6.5) and NNUHN (=6.38) due to the use of low tube current (mAs), with a mean of (=181.5) and (=230). Likewise, the (DLP) averages at SMCB (=1037.6) was the highest and the least at NNUHN (=206.4) which was affected by the (CTDIvol).

In the Abdominopelvic examinations, the (CTDIvol) averages were the highest at IHR(=51), this ascribed to the use of long scan lengths with a mean of (500mm), while the least (CTDIvol) average was at SRCH (=5.15) due to the use of lower tube current (mAs), with a mean of (=184.5). The highest (DLP) average was at SMCB (=2527) for the possible of use wide scan lengths (566.5mm). The (CTDIvol) average was close to the ACHR (=2200.47) average, while the least (DLP) average was at SRCH (236.25) due to the use of acceptable scan lengths. Its (CTDIvol) average was very low.

In the Lumber spine examinations, the highest average of (CTDIvol) was at ASHN (=43.05), due to the use of constant scan length (=350mm) and tube current (mAs) (=350) for all patients, the lower average of (CTDIvol) was at IHR due to the use of low tube current (mAs), with a mean of (125), while the highest DLP average was at ACHR (=1357.71) due to the use of wide scan lengths for some individual examinations with a mean of (350mm), and it had a relatively high (CTDIvol) average (35.4). The least (DLP) averages were at IHR (=223.5)which were affected by the lowest (CTDIvol) average (8.2), despite the use of wide scan lengths.

One of the factors that influenced the understanding of variables that affect the results was the non-availability of scan parameters for examinations at NSHN, SRCH, PRCHH, AHH and MHH. The data in these institutions was zeroed out periodically. Another reason for the lack of data from NNUHN, IHR, ZHT, YHB, PRCH and SRCH was that the CT-scanner was not functioning. BASRB refused to provide data to the researchers without giving the reasons

5. Conclusion and Recommendations

In summary, this study concluded the following: For the comparison of the average doses from Palestine NGO imagine facilities and the other countries, the averages of (CTDlvol) for the Brain CT examination in our facilities were less than the average (=51.77) of other countries except Iran (=43) while the (DLP) average was near to the other countries except Syria (=793) and Iran (=700). For the Chest examination in our facilities the average of (CTDlvol) was less than average (=12.82) of other countries except Iran (=10). While the (DLP) average (=510.3) was around the other countries except Iran (=330) and Kenya (=895). For the abdominopelvic examination. In our facilities the average of (CTDlvol) was higher than the averages of other countries except Syria, while the (DLP) average (=1070.66) was the highest compared to the other countries. For the lumbar spine examination, in our facilities the average (=25.31), (CTDlvol) was lower than the others except Kenya (=20), while the (DLP) average (=682.69) was the least average compared to the most other countries. Most these variations due technical factors and unalterable protocols that have their effect on the average at Palestine NGO imagine facilities.

The diagnostic reference levels (DRLs) should be taken on a large scale. The CT patient radiation doses in West Bank private and NGOs hospitals have been inspected and compared with similar studies in different countries such as Australia, French, Japan, Syria, Kenya, and Iran. This work surveyed 3052 CT examinations from 20 different hospitals distributed all over Palestine. Another noticeable variation concluded was in the comparison among the Palestine NGO imaging facilities that were observed in all facilities and examinations except the chest, that relatively low variations were observed. All these variations are closely related to the type of examination, protocol that applied. In light of the above outcomes, the following recommendations are proposed:

1. Training courses should be held to qualify CT technicians.
2. Protocols should be updated and modified to stay at the cutting edge of technology.
3. The ministry of Health is requested to establish a more rigorous monitoring system for the use of radiation.
4. Moreover, further studies should be conducted to detect the impact of radiation exposure on children and pediatrics.

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