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Research Paper

Measurement of Radiation Doses in Computed Tomography and Estimated Radiological Risk factor of Cancer - Libya

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Abstract
The aim of this study is to evaluate the radiation doses received by adult patients undergoing six common routine types of CT scans in Libya. These types cover the Head, Neck, Chest, Abdomen, Pelvis and Trunk. This work consists of measurements of (119) patients examinations in (1) government Hospital. The average doses area $CTDI_{vol}$ Volume computed tomography dose index ($CTDI_{vol}$) and dose-length product (DLP) were measured for each patient for each examination. The corresponding average effective doses were calculated from the DLP measurement for each scan using NRPP X-Dose software online. The risk rate of developing cancerous tumors as a results of exposure to radiation doses during diagnostic medical applications was also measured using a CT scanner, and the results were compared with these derived from similar surveys published by the United Nations Scientific Committee on the effects of Atomic Radiation (UNSCEAR, 2000,2007). Current measurements will provide a useful starting point and baseline for setting National diagnostic reference levels for the first time. These results can be used in the future to evaluate the populations collective dose of medical exposure and risk of cancer from CT Scan applications.
Keywords: CT, Effective Dose and Radiation Risk factor.

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I. Introduction

With the rapid scientific and technical development in the field of computed tomography (CT) and the increasing demand for it and reliance on it as an accurate diagnostic method for several diseases, it has become necessary to study and evaluate the radiation doses to which patients are exposed during various examinations due to their association with an increase in the radiation dose received as well as an increase in the degree of risk to their safety. However, some epidemiological studies have associated CT during childhood with an increased risk of radiation-induced malignancies [1-4]. Even if the outcomes of these studies are still controversial [5-7], a sensible use of the modality is of common sense. It requires strict adherence to the principles of radiation protection – justification and optimization of the patient radiation exposure [8]. At the core of the optimization principle is the establishment of diagnostic reference levels (DRLs), first proposed by the International Commission on Radiological Protection (ICRP) [9] and subsequently introduced into European legislation [10-11]. DRLs are suggested action levels above which a facility should review its methods and determine if acceptable image quality can be achieved at lower doses. An approach to establishing DRLs in CT had been proposed by ICRP [12-13], using two primary metrics: Dose-Length Product (DLP) and Volume Computed Tomography Dose Index (CTDIvol). National DRLs (NDRLs) in CT have been established in many countries [14-15]. Most of these NDRLs are defined for a single acquisition (i.e. phase), a standard patient morphology and are based on an anatomical region [16, 17, 18]. However it is evident that patient radiation dose depends on the number of acquisitions and on the patient's morphology. Likewise, patient radiation dose depends on the clinical indication, as image quality requirements are directly determined by the clinical purpose of the examination. This has been acknowledged, at least in part, by some NRDLs systems [13, 14, 16, 17, 19, 20,15]. However, none of these NDRLs studies has simultaneously involved a large number of examinations, clinical indications and patient size.

The primary of this study was to study current of radiation doses for common clinical indicators in CT scans of adults in a public central government Hospital in a city in western Libya and to evaluate patient radiation dose as a function of patient characteristics. This scientific study aimed to establish Libyan national

DRLs, and also aimed to prove that the clinical indicators, as well as calculating the risk cancer for the patient as a result of exposure to high radiation doses, and comparing them to global levels documented in several developed countries, and therefore all the reasons that contribute to improving the dose must be taken into account. The methodology, results and proposals in this study can serve as an important starting point for the national radiation protection authorities in future in the status of Libyan DRLs which may need to implement such a study on a large scale within central hospitals in the entire cities of the Libyan country.

II. Methods:

This was a retrospective cross-sectional study conducted in One (1) CT scan facility, random sampling. The study variables were dose length product (DLP) and volume-weighted CTDI (CTDIvol) for the radiation doses for head, , neck, chest, abdomen, pelvic and trunk.

The average values recorded for each examination were according to the anatomical region. To calculate the approximate effective dose is to multiply the DLP by a conversion factor that we call 'k'. This conversion factor is dependent on the body part(s) being scanned, and the patient age. The effective dose (mSv) was calculated from the product of the dose length (mGy) for a CT scan for each organ. The risk rate was also calculated using the X-ray risk online program and compared to global levels documented and published in several countries.

III. Results:

Tab. 1—Shows samples distribution according to size, gender based on age.

Gender	Percentage%	Age		
		Minimum	Mean average	Maximum
Male	58(69.02)	16	47.655±4.278(8.97%)	80
Female	61(72.59)	21	46.196±4.48(8.98%)	87

Tab. 2—Shows the sample distribution for each anatomy region CT examination.

Organs	Percentage of Males %	Percentage of Females%	Total Percentage %
Head	7(70%)	3(30%)	10(8.4%)
Neck	9(42.86%)	12(57.14%)	21(17.64%)
Lung	8(61.53%)	5(38.46%)	13(10.92%)
Abdomen	14(26.47%)	20(58.82%)	34(28.57%)
Pelvic	9(60%)	6(40%)	15(12.6%)
Trunk	11(42.30%)	15(57.69%)	26(21.84%)
Total	58(48.73%)	61(51.26%)	100%

Tab. 3—Shows effective Dose from DLP at Head, Neck, Lung, Abdomen and Pelvis at 120 tube voltage using conversion coefficient, k(mSv/mGy*cm).

Anatomic Reign	Voltage (V)	Scan Time (sec)	CTDI vol (mGy)	DLP mGy/cm	Conversion coefficient, k mSv/(mGy/cm)	Effective Dose (mSv)
Head	120	0.75	56.15	937.1	0.0021	1.97
Neck	120	0.75	21.414	579	0.0059	3.42
Lung	120	0.75	16.830	671	0.014	9.40
Abdomen	120	0.75	16.1	849	0.015	12.74
Pelvis	120	0.75	17	839	0.015	12.60
Trunk	120	0.75	16.4	1081	0.015	16.22

Tab. 4—Comparison of the effective doses (ED) of CT examinations at tube voltage 120 kV for selected organs worldwide.

Organs	Present work Effective Dose in mSv From DLP	Prevlous Works (Effective Dose In mSv)			
		D. Hart et NRPB W4 [13]	AAPM 96 [16]	Eugene C.L.in, Md [17]	Tsapakl et al [18]
Head	1.97				
Neck	3.42	1-2	1-2	2	---
Lung	9.40	8	5-7	7	10.9
Abdomen	12.74	10	5-7	10	7.1
Pelvis	12.60	10	3-4	10	9.3
Trunk	16.22				

Tab. 5—Shows Approximate risk factors for patients of different ages from effective doses from CT for Head, Neck, Lung, Abdomen, Pelvis and trunk.

Organ	Voltage (KV)	Effective Dose From DLP mSv	Age					
			Risk Factor (%) Incident Per Population					
			Age 25		Age 40		Age 55	
			1	2	1	2	1	2
Head	120	1.97	0.021 1:4823	0.041 1:2412	0.012 1:7286	0.030 1:3643	0.0091 1:11006	0.018 1:5503
Neck	120	3.42	0.031 1:3180	0.063 1:1590	0.021 1:4804	0.042 1:2402	0.012 1:7257	0.031 1:3629
Lung	120	9.40	0.121 1:823	0.243 1:412	0.080 1:1244	0.161 1:622	0.053 1:1879	0.110 1:939
Abdomen	120	12.74	0.155 1:651	0.31 1:325	0.101 1:983	0.204 1:491	0.067 1:1485	0.135 1:742
Pelvis	120	12.60	0.152 1:658	0.303 1:329	0.101 1:955	0.201 1:497	0.201 1:1502	0.133 1:751
Trunk	120	16.22	0.120 1:511	0.391 1:256	0.130 1:722	0.260 1:386	0.086 1:1166	0.172 1:583

IV. Results:

A total of (119 patients) were examined with an average age of (47.85) years. was collected from (1) CT scanners in (1) Central Government Hospital. After the data validation process, (119) CT examinations were analyzed. This included 24% Head, 21% Neck, 14% Lung, Abdomen 14%, 9% Pelvis and 11% Trunk.

The DRLs were as follows; for head CT scan - the average CTDIvol was 56.15 mGy and the average DLP was 937.1 mGy.cm; for Neck CT the CTDIvol was 21.41 mGy and the DLP was 578.5 mGy.cm; for Lung CT, the CTDI volume was 16.83 mGy and the DLP was 671 mGy.cm; for the abdomen CT, the CTDI volume 16.1 mGy and DLP 849 mGy.cm; for the Pelvic CT, the CTDI volume 17 mGy and DLP 839 mGy.cm and for the Trunk 16.128 mGy and the DLP was 1081 mGy.cm, respectively.

V. Discussion:

With the increase in scientific and technical development in the field of medical technology, the demand for CT scans and reliance on them as a means of diagnosing many diseases has increased in all countries of the world. Therefore it has become necessary to evaluate the short- and long-term biological risks associated with the radiation doses that patients receive during examinations and those related to the sensitivity of organs and tissues and the degree of risk and work to reduce them by studying all the factors that lead to an increase in radiation doses for patients undergoing CT examinations. As the risk of cancer accumulates with the patient’s lifetime accumulation of radiation exposure the effective dose calculation helps to quantify stochastic risk of carcinogenesis. During diagnosis, in order to lessen extraneous radiation to patients, it is necessary to determine what amount of radiation exposure has occurred [21].

A total of (119) patients were randomly selected from (1) CT scanners in (1) Central government Hospital, during the period from Jun - Dec 2023. The information collected was divided and classified into Six anatomical areas that underwent a CT scan, This included 10(8.40%) Head, 21(17.64%) Neck,13(10.92%) Lung, 34(28.57%) Abdomen, 15(12.60%) Pelvis and 26(21.84%) Trunk. after the data validation process all information was analyzed and studied according to the parameters used for each examination to achieve the objectives of the study.

Table.1.
It gives a general picture of the sample size and division based on the number and sex, indicating the proportion of each of them participating in the study sample where men’s were 58 patients (69.02%), mean average age was 47.655±4.278 years, the youngest was (16) years and the oldest 80 years, 61 women (72.59%) with mean average age was 46.196±4.48 years, the youngest was (21) years, the oldest (87) years.

Table.2. provides a detailed and complete explanation of the number of examinations studied based on the anatomical area, the type of examination and the proportion of men's and women's participation in each examination.
For CT examinations mentioned, Effective Dose for all CT examination, ED DLP (result from DLP to ED conversion factor k) were 1.97 mSv for Head, for 3.42 mSv for Neck, , 9.40 mSv for Lung, 12.74 mSv for Abdomen, 12.60 mSv for Pelvis and 16.22 mSv for trunk as showed in (Table 3).

(Table 4) Showed the CT DLP levels were comparable to those reported by European countries. For the adult groups, Abdomen, Pelvis and Lung CT dose indexes were slightly higher whereas those for head examinations were slightly lower than the European countries' data. Effective CT radiation doses are a limited dose indicator rather than an absolute indicator where the private clinic's effective radiation doses were within the same range as those in some European countries and showed the same trends between different CT scans. There were differences in the total number of patients per CT examination in this study and the total number of patients in this study did not correspond to the number of patients in previous studies whose results were compared to the results of the current study. The recording of patient radiation dose indicators also provides the advantage of obtaining evidence of the patient's individual cumulative doses and such population exposure dose.

To understand the impact of age on dose, age 25, 40 and 55 were considered in this experiment. It is observed that risk factor decreases with the increase of age. Risk factor were found considering the number of scan as (single examination) and (double examination). It is evident that risks were increased with the increasing number of CT examination. In case of Pelvis CT, 12.60 mSv ED was found. Considering the patient as male of age 25 years and experienced two pelvis CT scans in his whole life span then the associated risk of cancer is 1 among 329 population and the risk factor is 0.30% which is observed as the highest among all. The second highest risk is observed for Abdomen ED was found 12.74 mSv at the age length of 25, if the patient is scanned a double abdomen CT, then the probable risk of having cancer is 1:325 and risk factor is 0.31%. The third highest risk is observed for Lung ED was found 9.40 mSv at the age length of 25, if the patient is scanned a double Lung CT, then the probable risk of having cancer is 1:412 and risk factor is 0.24%. A comparison of present measurement with internationally recognized data for CT doses is presented in (Table 5).

It is difficult to compare the present data with reference data since almost each study has considered the different irradiation conditions. The proper risk of fatality from CT is a burning context of dispute. Accurate carcinogenic risk from low doses of ionizing radiation involves uncertainty. Although it is generally well accepted that there is a meaningful risk from doses greater than 100 mSv, there is debate regarding the risk from lower doses [22,23] but still this is a probability of low dose cancer risk by ICRP-99 [24].

The results of this study and previous studies published in some European countries showed that it is necessary to develop a strategy to reduce the dose of computerized CT radiation as a fundamental step and should be integrated into the programs of developing the quality of radiation diagnostic services in hospitals and service delivery centers in the public and private sectors. The study also showed that continuous monitoring of CT dosage levels for patients is an important element of the radiation dosage reduction strategy for patients undergoing diagnostic examinations and with the increasing demand for CT scans, this contributed to an increase in the average radiological background of the environment, which in turn contributes to an increase in the risk rate of cancer to humans. and therefore continued monitoring of CT radiation dose levels has become a major concern for both health-care providers and manufacturers of radiation-emitting devices, health physics departments and radiation prevention.

VI. Conclusion:

This study confirmed the urgent need to improve CT parameters in order to reduce Radiation dose to patients. This can be achieved through extensive training of all CT radiologists in optimizing CT acquisition parameters. It is also recommended to perform calibration tests periodically and constantly check doses using new equipment to ensure that the values within a safe and well-justified range.

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