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Evaluating the Average Exposure Levels Provided to Neck and Cervical Spine CT Patients

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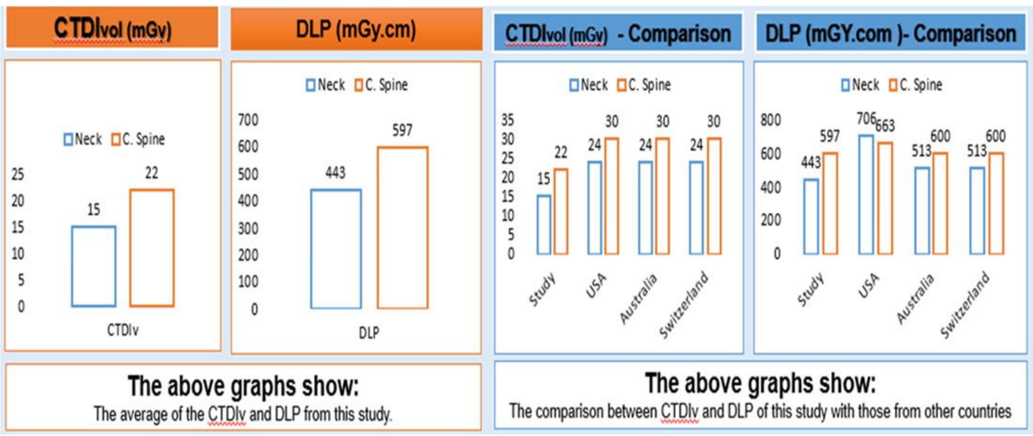
ABSTRACT

To apply the radiation protection optimization concept, the current study compares the average doses utilized to produce the most popular CT scans of neck and cervical spine at the Al-Makkased Hospital in Jerusalem and its affiliated medical facilities around the world. The study employs a hybrid research methodology concept. The current study compares the average doses utilized to produce the most popular CT scans of neck and cervical spine at the Al-Makkased Hospital in Jerusalem and its affiliated medical facilities around the world. The study employs a hybrid research method. It thus fits into both descriptive and observational research. Its objectives are to evaluate the CT dose descriptor averages (CTDI and DLP), compare them to those developed in other nations, and illustrate how radiation protection principles, particularly the optimization principle (ALARA), are applied. According to the imaging facility's examination storage for each exam, studies show that there are regular variations in the number of CT scans obtained, with the cervical spine accounting for 87% of all such variations and the neck for 13%. The scan parameters (kvp), (MAs), scan length, and variations are related to the protocol itself or the choice made by the CT engineer.

GRAPHICALABSTRACT



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Introduction

Over the past century, techniques for medical imaging have been developed to create and process images of various body parts. These techniques include CT, MRI, PET, fluoroscopy, ultrasound, mammography, and X-ray. Numerous diseases have been identified by these techniques [1]. Axial computed tomography (CAT), often known as computed tomography (CT), provides a three-dimensional form (x, y, and z). In this modality, the subject is rotated around by specialist x-ray equipment, which gathers views and creates a cross-section image of the entire human body or a particular anatomical region. CT provides more information and better contrast resolution than traditional X-rays. However, due to increase exposure to ionizing radiation, the risk to a patient is higher than with regular X-rays [2]. Due to the risk of ionizing radiation, the patient's radiation dose level depends on the variables "Kilovoltage Peak (kVp), Milliampere (mA), Time in Seconds (s), and Scan Length." Through realistic optimization, the radiation dose in CT should be kept to a minimum as low as reasonably achievable (ALARA) philosophy. In addition, only the required examinations should be carried out, and the physician should justify each test, so it will help cut down on extra radiation exposure since the patient's cancer was caused by these examinations. To lessen the likelihood of developing cancer, low-level radiation should be employed. Even though there are not many hazards for any one person, the growing radiation exposure of population could eventually hurt public health and cause biological harm [3]. To help radiology professionals optimize their practice and accomplishments, this study sought to ascertain the typical doses administered by Al-Makkased Hospital during adults' CT-scan examinations. It also aimed to increase Palestinian students' understanding of the principles underlying optimization tools employed around the globe. The CT dose index (CTDIvol) and Dose Length Product are the most disparate measurements utilized in CT scans (DLP).

A. M. Tawfik *et al.* (2011) conducted a study to compare a standard 120-kVp acquisition to the image quality and radiation dose of a dual-energy CT of the head and neck. The last 32 patients who received regular SECT (120 kVp) on the same dual-source scanner were compared with the overall 32 patients who underwent the H&N (tube voltages 80 and Sn140 kVp). Images obtained using a SE mode and WA images from the two DE tubes were compared with radiation doses and attenuation data were taken for the sternomastoid, submandibular, and internal jugular vein, and also they compared the tongue's muscles. Five anatomical levels of the objective image noise comparison were made. Two blinded readers used 5-point grading scales to compare the subjective quality of the images. They discovered that CTDIvol was 1.5 mGy (12%) lower with DE compared with SECT (P .0001). At any anatomic level, there was no discernible difference in objective noise between DE and SECT (P>.05). Between DE and SECT, no discernible variations in attenuation values were found (P>.05). At any of the 5 anatomic levels, there were no discernible differences between DE and SECT in terms of subjective picture quality scores (P>.05). For common diagnostic applications, DE-derived WA pictures of the H&N are equivalent to the conventional SE acquisitions. Without incurring a radiation dosage penalty, numerous additional picture datasets can be acquired [4].

In 2010, P. Deak, Y. Smal, and W. Kalender compared the effective doses derived from Monte Carlo calculations with those derived from dose-length product (DLP) calculations for various body regions and computed tomographic (CT) scanning protocols, conversion factors for the new 103 recommendations for adult and pediatric patients published by the International Commission on Radiological Protection (ICRP) should be determined. A 64-section multidetector CT scanner's effective dose values for the Oak Ridge National Laboratory phantom series, which includes phantoms for newborns, 1-, 5-, and 10-year-old children, and adults, were calculated using Monte Carlo techniques. Five anatomical regions-the head, neck, chest, abdomen, and pelvis-were taken into account for each phantom. Various voltages of spiral scanning methods were put through Monte Carlo simulations. Utilizing the guidelines from ICRP publications 60 and 103, the effective dose was calculated. In general, conversion factors produced from Monte Carlo simulations led to lower values for adults with both ICRP publications when the calculated effective doses were compared with those derived from the DLP. For ICRP publications 60 and 103, values that were as much as 33% and 22% lower than previously published data were discovered, respectively. Effective doses based on Monte Carlo estimates were greater for pediatric patients than those determined by DLP and previously reported conversion factors (e.g., for chest CT scanning in 5-year-old children, an increase of about 76 percent would be expected). When the tube voltage was changed for children, a difference was seen in conversion factors of up to 15%. There was no evidence of voltage dependence in adults. For both sexes, distinct conversion factors from DLP to effective dose should be stated, and they should take into account the current ICRP guidelines. New conversion factors tailored to the spectrum in use for pediatric patients should be established [5]. P. M. C. Hillier, C. Shrimpton, M. A. Lewis, and M. To examine patient doses from CT scans in the UK, Dunn i003 undertook a study. In general, questionnaires were used to gather scan information.

Both for samples of individual patients and the standard protocols set up at each scanner for the 12 popular types of CT examination on adults and children. For each scan sequence, the standard dose indices CTDIw and CTDIvol were estimated using this information and previously published scanner-specific CT dose index (CTDI) coefficients. Wide variability in dosages for conventional protocols between CT centers was still noticeable when compared with a 1991 UK assessment. Although doses for multi-slice (4+) (MSCT), compared with single-slice (SSCT) scanners, were somewhat higher, the mean UK doses for adult patients were often up to 50% lower than those for 1991. CTDIvol values for MSCT were largely consistent with 2001 survey results from Europe. As initial instruments for increasing patient protection, the UK national reference doses for examinations on adults (separately for SSCT and MSCT) and children were derived using the third quartile values of these dose distributions. Through the continued collection of more survey data, the study has developed the PREDICT (Patient Radiation Exposure and Dose in CT) database as a reliable national tool for tracking dose trends in CT [6].

S. J. Foley, M. F. Mcentee, and L. A. Rainford (2012) collected radiation doses for the most frequently done CT examinations to undertake a study on Irish CT diagnostic reference levels (DRLs). A pilot study looked into the most common CT scans. To capture the CT parameters for each of the 9 CT examinations performed over the course of 12 weeks, 40 CT sites were then asked to complete a survey booklet. To determine a mean site CTDIvol and DLP value, dose data-CT volume index (CTDIvol) and dose-length product (DLP)-were recorded for a minimum of 10 average-sized individuals in each category. By aggregating all results, a DRL was determined for each site and nation using the rounded 75th percentile. The outcomes are contrasted with global DRL data. They discovered 3305 patients' data had been collected. 34 scanners from 30 sites, or 54% of the total nationwide, responded with data. Every piece of equipment featured a multi-slice (1-228 slices) capacity. DRLs are suggested using CTDIvol (mGy) and DLP (mGy cm) for the following CT scans: CT head (66/58 and 940, respectively), sinuses (16 and 210, respectively), cervical spine (19 and 420, respectively), thorax (9/11 and 390, respectively), high high-resolution resolution CT (7 and 280, respectively), CT pulmonary angiography (13 and 430, respectively), multiphase abdomen (13 and 1120, respectively). These numbers are in line with other international research and lower than the DRLs in use today. Across sites, there are significant differences in the mean dosages. On the most regularly performed CT examinations, Irish CT DRLs are offered. There is a lot of room for exam optimization, as seen by the differences in dose between CT departments and identical scanners [7].

Problem statement and significance of study

The use of ionizing radiation in medical imaging poses a constant risk to the subject being examined for health, particularly because the thyroid gland is particularly sensitive to radiation [2]. Even though CT has a higher radiation exposure than traditional radiography, the standard dosages are unknown. This study aimed to calculate the radiation exposure for patients during CT scans. In addition, we noted that no real-world criteria had been used to optimize and manage the quality of CT scans. The health risks associated with radiation exposure from a routine CT scan can be contrasted with background radiation levels. Taking into account the rising number of persons having CT scans. However, the impact of CT radiation exposure on societal health issues could be substantial. Although there is a lot of disagreement with this notion to prevent needless CT scans.

Research objectives and inquiries

Significance of the study

Higher radiation doses for patients are associated with CT examinations. There was more variation in exposure and technical aspects amongst medical imaging facilities during our practice at our facility. All of these investigative methods help radiology specialists improve their practices and results, lowering the patient dose, and they will increase Palestinian medical imaging specialists' understanding of the ideas behind numerous optimization tools utilized around the globe.

Objectives of study

- To estimate the typical CT dose descriptors (CTDIvol and DLP) applied to the adult neck and cervical spine CT scans at Al- Makkased Hospital.
- To examine our current position by comparing regional average doses to established worldwide standards.

Materials and Methods

Research design

This research is quantitative and descriptive (based on observation). By evaluating the CT dose descriptors (CTDI) and (DLP) at Al-Makkased Hospital and their differences from those in the international, was done to define the dose.

The conducted cervical spine and neck CT examinations were used to gather the CT dose descriptors. From January 1 to December 31, 2018, this study was carried out over 12 months.

Population and selection

The study's target group included adults who underwent routine cervical spine and neck CT scans throughout one year at Al-Makkased Hospital. The purpose of the study, which employed a convenience sample methodology, was to compile all of the cervical, neck, and spine cases in CT performed in 2018. This implies that after the patient has been examined in this facility, we took all examinations that have been saved on the computer system by the medical imaging team. The sample consisted of 222 examinations for cervical (n = 193) and neck CT scans (n = 29) patients.

Inclusion criteria

Data were exclusively gathered for adult cervical spine and neck CT routine examinations from the Al- Makkased Hospital in Jerusalem. And the age group included in our study ranged from 18 years old and over. For tests with several sub-scans, this study only included non-contrast scans.

Exclusion criteria

The authors did not include any of the additional CT-scan examinations or methods in our analysis. In addition, patients under the age of 18 years old were excluded from the study. Due to the complexity of dose calculation, any examination that involves the neck with another organ in the same sequence was ruled out.

Data collection

To prepare the national dose survey easier, the Al-Makkased Hospital in Jerusalem's CT scanners as well as clinical institutions' demographics, which included information on the CT scanners' features, were initially studied. Tables 1 and 2 provide explanations of KVp, mAs, scan length, manufacturing, and various detectors about this. We used the PACS system to gather the information displayed in each CT scan, and data was subsequently filled out on an Excel document that was originally required.

Data analysis

The data were examined using an Excel spreadsheet, where the estimations of the average and standard deviation of CTDI and DLP dose descriptors, the number of CT scans, and other acquisition parameters were made. In addition, the figures that demonstrate the discrepancies between our imaging facilities and other nations in terms of dosage descriptor variations are included.

Results and Discussion

Count of examinations

This study comprised 222 individuals who had CT scans, of which 87 percent (n=193) had cervical scans and 13 percent (n=29) had neck scans. The survey reveals differences in the number of CT scans retrieved via PACS, and Table 3 lists the precise number of CT scans that are available. Furthermore, it counts for each sort of test.

Totally according to the examinations and their classifications based on gender (male or female), 45 percent of neck examinations were performed on females, whereas 55 percent of cervical spine examinations were performed on males, as displayed in Figure 1.

Acquisition parameters

The average of each acquisition parameter was calculated using the imaging facility's helical acquisition geometry. The various tube voltage (kVp) values, listed in Table 1, were recorded during the cervical spine and neck tests. For the cervical CT scans, the maximum average tube current (mAs) was measured at an average of (300), with extremely varied acquisition conditions.

Average doses (dose descriptors) for cervical spine and neck CT examinations at Al-Makassed hospital imaging faculty

The average of the CT dose descriptors (CTDIvol and DLP), which were determined and utilized to estimate doses in all the study's participating institutions, were seen on the cervical spine and neck CT examinations in Table 2.

Table 1: The averages (means) of CT dose descriptors (CTDIvol) and (DLP) for each group of CT-scan examinations at Al-Makassed Hospital in Jerusalem

Examinations	Average. CTDIvol (mGy)	Average. DLP (mGy.cm)
Neck	14.57(2.59±)	442.66(156.20±)
C-spine	21.66(1.48±)	597.04(100.1±)

Table 2: Average doses (dose descriptors) in CT imaging at Al-Makkased Hospital compared with other averages

	Our study (averages)		Ireland 2015 [8]		Switzerland 2015 [8]		USA 2013 [8]		Australia 2015 [8]	
Examination	CTDIvol	DLP	CTDIvol	DLPlds	CTDIvol	DLP	CTDIvol	DLP	CTDIvol	DLP
C-spine	21.66 (1.48±)	597.04(100.1±)	19	420	30	600	30	663	30	600
Neck	14.7(2.59±)	442.66(156.20)	****	****	23.6	513	24.3	706	23.6	513

**: The country that did not establish an average neck examination*

Table 3: The average of the acquisition parameters that were used at Al- Makkased in Jerusalem

Examination	Kvp	mAs	Scan length(mm)
C-spine	140	300	251
Neck	120	300	251

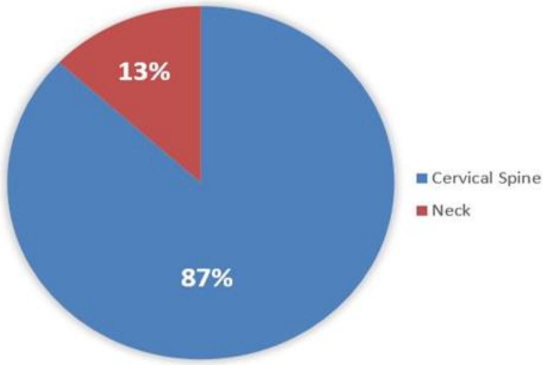

Figure 1: The percentages of examinations and their classifications

The Figures 2 and 3 illustrate the average CT dose descriptors (CTDIvol, and DLP), which are presented in all the study's participating facilities.

Averaged CT dose descriptors, (CTDIVOL and DLP) compared with other countries averages

This study compared the data from Ireland, Switzerland, the United States, and Australia to assess how our average doses (dose descriptors) differ from those reported elsewhere in the world to apply the optimization principle.
Figure 7 presents the differences between the comparative average doses for each, where its averages were attained in a different period, although the neck examination was not established in Ireland and was regarded as an exclusion examination in the study. This table will provide further information about the differences between the typical dose descriptors used in our investigation and those used in other studies conducted in other nations. For cervical spine and neck tests, the average dose descriptor (CTDIvol) discrepancies between Al-Makkased Hospitals and other nations are, respectively, Ireland, Switzerland, the USA, and Australia, as illustrated in Figure 4.

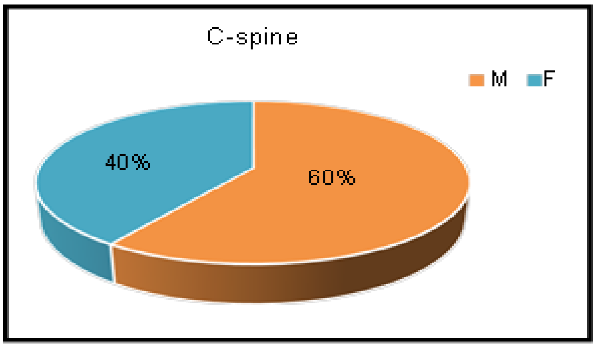

Figure 2: The percentages of examinations number and their classifications based on gender (male or female)

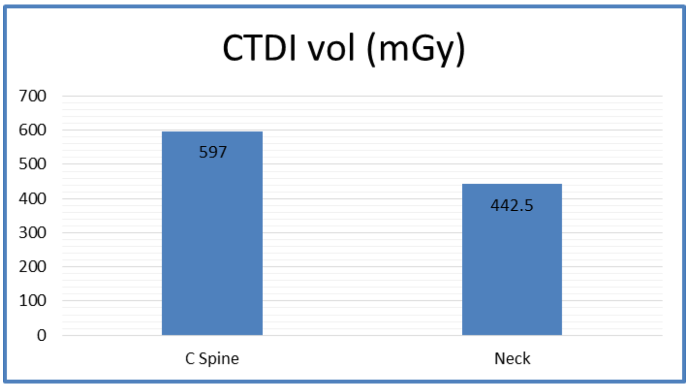

Figure 3: The average CT dose descriptor (CTDIvol) at Al-Makassed Hospital for the (Cervical spine, Neck) CT examinations

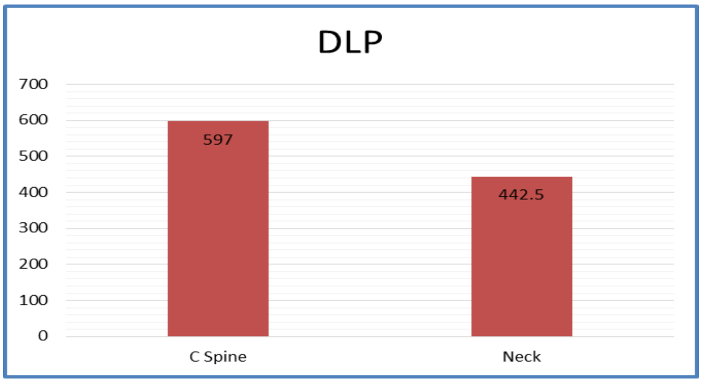

Figure 4: The average CT dose descriptor (CTDIvol) at Al-Makassed Hospital for the (Cervical spine, Neck) CT

Ireland, Switzerland, the USA, and Australia are the countries with the largest average dose descriptor (DLP) disparities for cervical spine and neck examinations between Al-Makkased facilities (Figure 5).

Cervical spine CT examination

Ireland's average CT dose descriptor (CTDIvol) for cervical spine examinations was lower than our facility's (19 mGy), and our facility's (21.66(1.48 mGy) was lower than Ireland's average as well as the USA, Switzerland, and Australia (30 mGy)), as displayed in Figure 6.

Neck examination

Our facilities' average dose descriptor (CTDIvol) for neck examinations was (14.7(2.59) mGy, which is lower than that of other nations, as depicted in Figure 8.

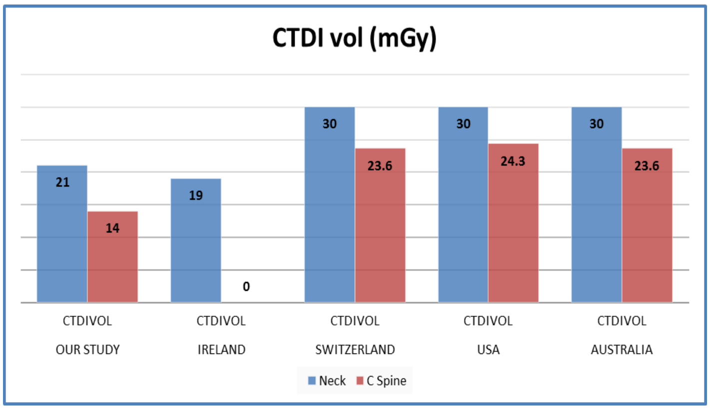

Figure 5: The CT averages of dose descriptor (CTDIvol) differences between Al-Makassed hospitals for the cervical spine, neck, and other countries

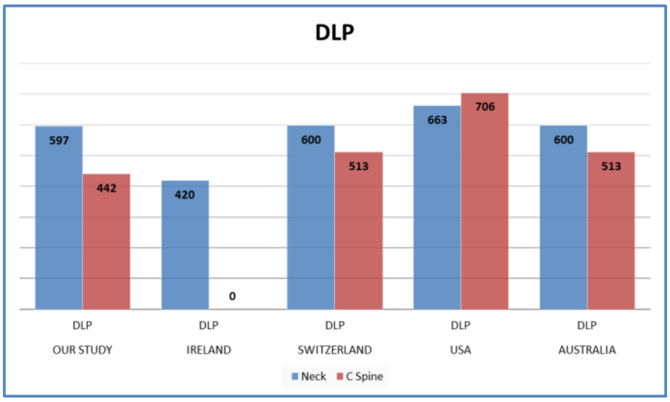

Figure 6: The CT averages of dose descriptor (CTDIvol) differences between Al-Makkased hospitals for the cervical spine, neck, and other countries

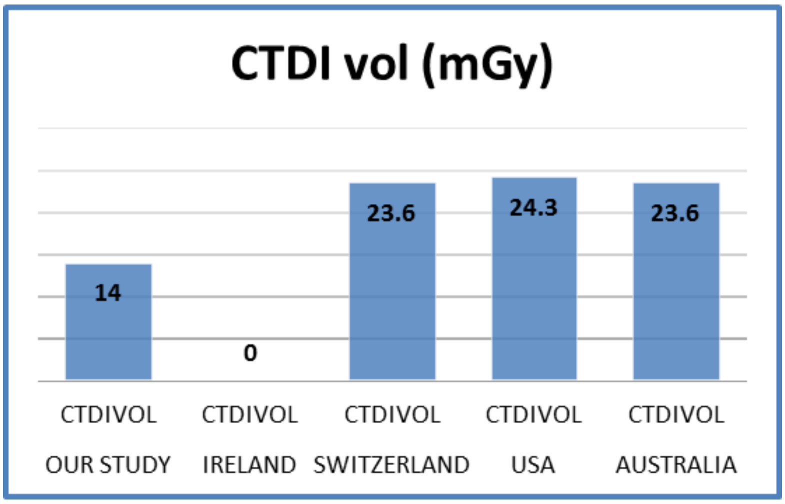

Figure 7: The average CT dose descriptor (CTDIvol) at our facilities was lower than in Switzerland, the USA, and Australia, but higher than in Ireland for the cervical spine examination

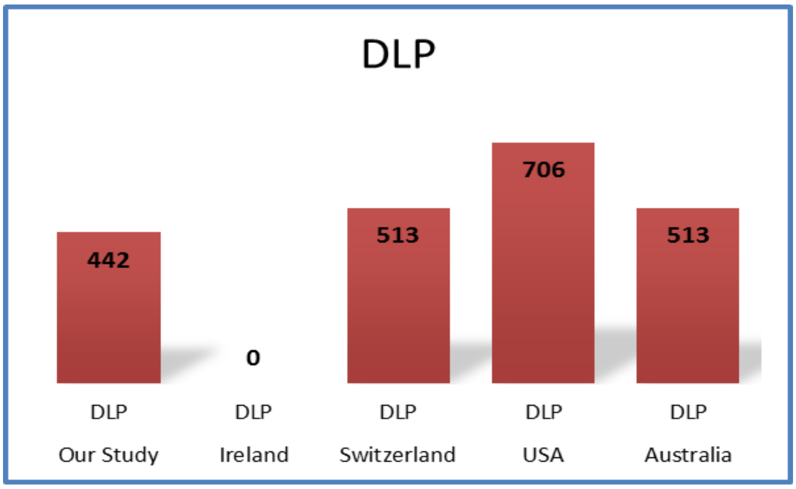

Figure 8: The average CT dose descriptor (DLP) at our facilities was the least among the others for the Neck examination

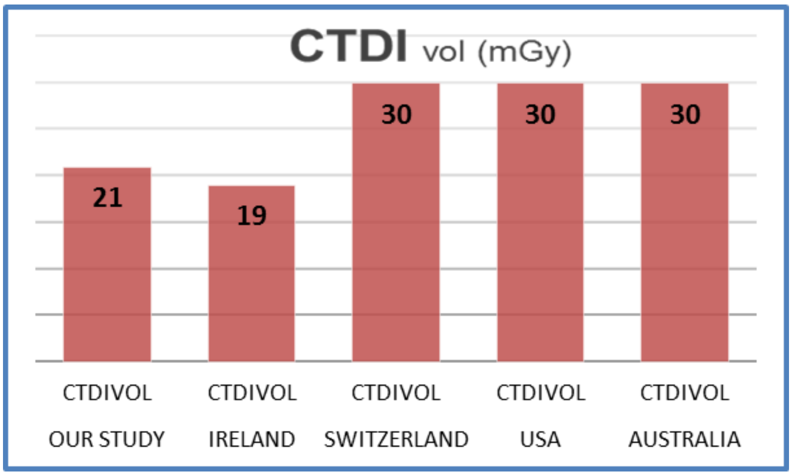

Figure 9: The average CT dose descriptor (CTDIvol) in our facilities was the least among the others for the Neck examination

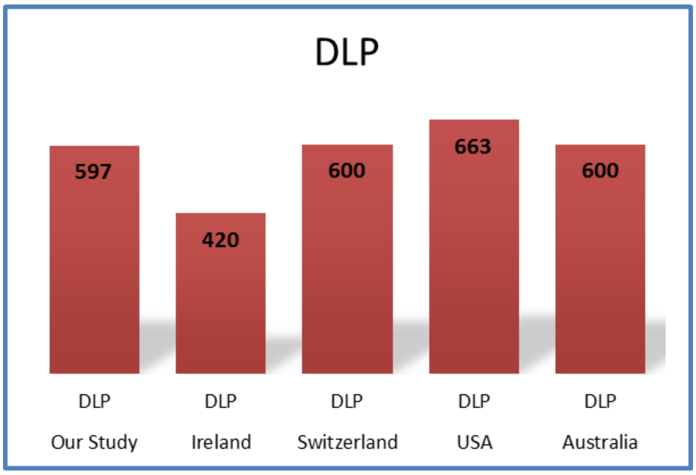

Figure 10: The average CT dose descriptor (DLP) in our facilities was the least among the others for the Neck examination

At roughly (442.66(156.20) mGy.cm), the (DLP) average is the lowest among the other nations, as demonstrated in Figure 9 and 10.

The authors conduct this descriptive study to analyze and assess the typical doses at the Al-Makkased Hospital in Jerusalem when doing normal adult cervical spine and neck CT scan examinations. The study revealed variations in the quantity of obtained CT scans. Evidently, the cervical spine accounted for 87% of all examinations at the imaging facility, and neck accounted for 13% of all examinations. This is typical concerning that the cervical examination is requested for examinations in the Medical Imaging Department more frequently than the Neck examination. Other variations in the acquisition parameters (kvp), (mAs), and scanning length were discovered. These variations may have been caused by the choice of a CT technician or by the protocol itself. The cervical spine examination in our study required deeply penetrated the X-ray photons. Hence, the tube voltage (kvp) at that examination was (140), whereas the tube voltage at the neck examination was (120). However, the tube current (mAs) for the neck and cervical spine examinations performed is the same (300). The patient's dose will change if this parameter is changed in any way. The average CTDI for cervical in our facility in 2018 is 21.66(1.48) mGy.cm, and we compared it with four other nations. The CTDI in Ireland in 2015 was 19 mGy.cm, which is lower than our results. The CTDI in Switzerland in 2015 was 30 mGy.com, which is higher than our results. However, the average CTDI for cervical in the USA in 2013 was the same as that of Switzerland, which is 30.

The DLP in our facility was (597.04(100.1)), but compared with the earlier studies, Ireland's DLP was (420), which is lower than our result (42%); Switzerland's DLP was 600, which is almost near to our facility (0.01%); the study in the USA was also close to our result, which is (663). However, we are less than 10% compared with the USA, and finally in Australia, the DLP was 600, which is the same as Switzerland (Kvp and mAs). As a result, we discovered that the results of our study (in DLP) are fairly comparable to those of international studies.

The USA value for CTDI was 24.3 which was higher than our result of 40%, and the last country that we compared was Australia which was a CTDI of 23.6 and was the same value as Switzerland where the percentage was higher than our country. The average CTDI for Neck examination in our facility was 14.7(2.59) mGy.cm. We compared this value with the same countries explained previously. Switzerland was 23.6 mGy.cm which is higher than our result of the average DLP for the Neck examination in our results was 442.66 (156.20); this value was compared with Switzerland, where the DLP value is 513, which is higher than our result (14 percent); the USA, where the value is 706, which is higher than our result (37 percent), and finally Australia, where the DLP was the same as

Switzerland, which is 513; the percentage was 14 percent. Al- Makkased Hospital's CTDI and DLP readings were all acceptable and within normal ranges compared with other nations.

Conclusion

From the above mentioned points, it is clear that cancer cells have developed extraordinary skill not to fight, but to defend and escape so as not to cost themselves much. Scientists in this field of research are still waiting to reveal other methods that may lead to a more understanding of how cancer cells overcome the immune response, and thus may help design effective immunotherapies against tumors. However, it has become clear that no treatment response is uniform, highlighting the need for individualized tumor analysis and the corresponding individual immunological/immunogenetic background to decipher, on the one hand, the specific pathways used by the tumor to thwart the immune system of hosts and, on the other hand, the latter's potential responsiveness. Immunotherapy should be synthetized with other pillars of cancer treatment, such as surgery, chemotherapy, and radiation to greatly increase the impact of each therapeutic modality.

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Authors' contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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References

[1]. Vañó E., Miller D.L., Martin C.J., Rehani M.M., Kang K., Rosenstein M., Ortiz-López P., Mattsson S., Padovani R., Rogers A. Authors on behalf of ICRP. ICRP Publication 135: Diagnostic Reference Levels in Medical Imaging. *Ann ICRP*. 2017, **46**:1 [Crossref], [Publisher]

[2]. Kazemi-Bajestani S.M.R., Mazurak V.C., Baracos V., "Computed tomography-defined muscle and fat wasting are associated with cancer clinical outcomes," *Seminars in cell & developmental biology*, 2016, **54**:2 [Crossref], [Google Scholar], [Publisher]

[3]. Mustafa Y.F., Chemotherapeutic applications of folate prodrugs: A review, *NeuroQuantology*, 2021, **19**:99 [Crossref], [Google Scholar], [Publisher]

[4]. Tawfik A.M., Kerl J.M., Razek A.A., Bauer R.W., Nour-Eldin N.E., Vogl T.J., Mack M.G., Image quality and radiation dose of dual-energy CT of the head and neck compared with a standard 120-kVp acquisition, *American Journal of Neuroradiology*, 2011, **32**:1994 [Crossref], [Google Scholar], [Publisher]

[5]. Deak P., Smal Y., Kalender W., Multisection CT protocols: sex-and age-specific conversion factors used to determine effective dose from dose-length product, *Radiology*, 2010, **257**:158 [Crossref], [Google Scholar], [Publisher]

[6]. Shrimpton P.C., Hillier M.C., Lewis M.A., Dunn M., National survey of doses from CT in the UK: 2003, *The British journal of radiology*, 2006, **79**:968 [Crossref], [Google Scholar], [Publisher]

[7]. Foley S.J., McEntee M.F., Rainford L.A., Establishment of CT diagnostic reference levels in

Archive of SID.ir

Ireland, *The British journal of radiology*, 2012, **85**:1390 [Crossref], [Google Scholar], [Publisher]
[8]. Huda W., Spampinato M.V., Tipnis S.V., Magill D., Computation of thyroid doses and carcinogenic radiation risks to patients undergoing neck CT examinations, *Radiation protection dosimetry*, 2013, **156**:436 [Crossref], [Google Scholar], [Publisher]

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