Statistical study for Radiation Dose Reference levels of Adult Computer Tomography Abdominal studies in Eldoret Kenya

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ABSTRACT

Objective: To establish dose reference levels for the adult abdominal CT scan modality at MTRH, Eldoret Hospital, St. Luke's Hospital and Medi heal Hospital in reference to the international DRLs.

Methods: A retrospective study, reviewed CT scans of 700 adult patients conducted in the 4 health institutions from Uasin Gishu healthcare system in a period of 1 year in the year 2021 using systematic and consecutive sampling. The Volumetric CT-dose index ($CTDI_{vol}$) and dose length product (DLP) length from the various adult CT abdominal scans were obtained.

Results: The mean $CTDI_{vol}$ was 8.1 (22.2) and the mean DLP values was 1699.1 (1053.1). Comparison by scan model it was observed that the median for the Total DLP and for the $CTDI_{vol}$ significantly differed by the model with the median for the Neusoft model being highest at 2538 mGy.cm and 10.3mGy respectively while those for the Siemens were the lowest for the two markers at 1318.5 mGy.cm for the DLP and 5.39mGy respectively. These findings were statistically significant with a p value of < 0.001. Comparison by the type of facility it was observed that the median DLP and $CTDI_{vol}$ values were significantly higher in the public facilities at 1668.8mGy.cm and 6.3mGy respectively when compared to private facilities at 1282.4mGy.cm and 5.9mGy with a p value of <0.001. The Local Dose reference level (LDRL) was set as the median value for $CTDI_{VOL}$ and DLP at 6.1mGy respectively.

Conclusions: The LDRLs for the adult patients undergoing abdominal CT examination in Uasin Gishu healthcare system were markedly lower than the regional and the international values for the same abdominal CT examination.

Keywords: CTDI: DLP: Radiology and Imaging: MTRH

BACKGROUND

Globally healthcare institutions in the developed world have improved their level of quality care by taking advantage of the advancement in imaging technology. This has led to an increase in the radiation burden due to the increased imaging procedures and therapy. As a component of quality, safety in radiation dosage exposure is paramount in the field of radiology therefore ICRP advocates for the principles of ALARA (As Low as Reasonably Achievable) in carrying out radiological examinations. Despite the emerging trend in embracing advanced imaging interventions, we are yet to locally develop national diagnostic radiation references protocols. Hence increased chances to high level of radiation dosage exposure during radiological procedures and therapies. The study has provided data on adult CT doses on studies of the abdomen at Moi Teaching and Referral Hospital, Eldoret Hospital, St. Luke's Hospital and Medi heal Hospital in Eldoret. As a result, provided a basis for setting regional DRLs., therefore form a basis for reference in Uasin Gishu county.

The CT scan is proving to play a critical role in the management of patients with various disease

presentation requiring imaging. To an extent it has replaced some of the invasive procedures to a minimally invasive procedure. Owing to the advent of multi detector CT scanners the risk of high radiation dose to the patients is increased(Mayo, Aldrich, & Müller, 2003). Thus, this necessitates actions geared towards dose reduction mechanisms that ensures patients safety and still maintain quality images (Little et al., 2008). There are limited studies so far showing the dose burden of the multi dector abdominal CT scan. The purpose of this study was to assess local doses for adult abdominal CT scan examination at MTRH and the 3private hospitals under the survey. Excessive radiation exposure can lead to stochastic side effects to the patients furthering the cancer burden. The survey has provided a basis for comparisons of dose references levels among Moi Teaching and Referral Hospital, Eldoret Hospital, St. Luke's Hospital and Medi heal Hospital with international DRLs. Hence formed a basis for setting regional DRLs.

Study Objective

To establish dose reference levels for the adult abdominal CT scan modality at MTRH, Eldoret Hospital, St. Luke's Hospital and Medi heal Hospital in reference to the international DRLs.

METHODOLOGY

Study Design

The study involved a retrospective review of CT scans from adult patients who underwent abdominal scans, in the past 6 months from the study period 2021. Retrospective analysis was utilized due to the disadvantages of prospective reviews as concerns time and resource constraints.

Study Area

Moi Teaching and Referral Hospital is the second largest National Teaching and Referral Hospital (level 6 Public Hospital) in the country. It is located in Eldoret town, Uasin Gishu county. It serves residents of Western Kenya region, parts of Eastern Uganda and Southern Sudan. (http://www.mtrh.go.ke,24/02/2020).It has an imaging and radiology department equipped with 3 functional CT scanners.It performs an average of 40 general CT scan examinations per day. Eldoret hospital is the oldest private healthcare giver since its inception in 1975 as a nursing home to a fully-fledged hospital with multi-disciplinary specialties' that include imaging department with a CT scan. It does around 8 CT scans a day. It is situated in Eldoret town Uasin Gishu county. Mediheal is a private hospital also located in Eldoret town, it has a modern imaging department with a functional CT scan. It carries out 10 CT scans in a day.St. Luke's as well is a private hospital with a fully-fledged imaging department with an operating CT scan doing averagely 12 CT scans per day. It is also serving the population of Eldoret and Western Kenya Region.

Study Population

The study population involved CT scans of adult patients who underwent abdominal scan.

Eligibility Criteria

i) Inclusion Criteria: Standard abdominal CT scans both contrast and non-contrast enhanced from adult patients.

ii) Exclusion Criteria: Incomplete standard abdominal CT scan dosimetry

Sampling Frame

The principal researcher obtained data from the registry at the CT department of the various facilities

included in the survey entailing abdominal CT scans dosimetry for the adult population. In the year 2020, 2100abdominal CT scans for the adults were done at MTRH. For the three private hospitals combined, 369 adult abdominal CT scans in the year 2020 were performed. Hence a total of 2469 CT scans for the 4 hospitals were done in the year 2020.

Sample Size

The study sample size was calculated based on the standard formula for estimating mean.

i) Formula:

$n = z^2 \sigma^2 / d^2$ where n is the sample size and σ^2 is the variance for the population.

ii)Workings:

$1.96^2 * 74^2/5^2 = 842$,n=842

Based on the formula, the sample size of the study was842 adult patients who underwent abdominal CT scans from the respective hospitals. And the distribution is as shown in table I below.

TABLE I: Showing Sampling Frame of Patient CT Scans

Facility	population	sample size
MTRH(public)	1000	692
Private hospitals	150	150
Total	1150	842

Sampling Technique

Systematic and Consecutive sampling technique was used to obtain data in the various respective CT scans dose tracking software's from the hospitals. Consecutive sampling was applied to the 3 private facilities. While systematic sampling using the interval K was used in MTRH.

Workings:

K=1000/692~2 where K= interval, k ~2

Hence selected the initial point randomly from the given list of the sample database then at every second interval chose the data as the sample until the list is exhausted.

Study Procedure

Information from the respective CT registry was obtained by the Principal Investigator following authorization from the departmental heads. Using a IAEA survey guide that captured the facility name, demographics, scanner model, dissymmetry's and relevant information pertaining to the study was retrieved, recorded and stored in password protected database. Data from the CT database systems from the Imaging and Radiology department in the respective hospitals were obtained retrospectively for a 6 months' period(2021) using the same type of dose management system. Data compilation, cleaning and analysis was performed.

Data collection

For purpose of determining the exposure related parameters on patient doses, typical exposure parameters

(e.g., kilovoltage (kVp), tube current (mA), exposure time, slice thickness, table increment and number of slices and phantom size) was collected from each hospital participating in the study. In order to consider the variations due to the different scanners from each hospital hence, standardized CT protocols was adhered to as provided by the specific manufactures for the CT scanners and which have been authorized by the International Commission on Radiation Protection (ICRP/IAEA).Abdominal CT examination protocols for routine or unique indications and other diagnostic tasks as prescribed may vary with each CT scanner machine. The regulatory authorities together with the manufacturers have set standards that are adhered to universally in respect to the CT scan model and for each modality being examined e.g. it is recommended that irrespective of the machine type, a CT phantom of standard diameter 32 in size should be selected when performing body or Abdomen scans (EC 1999). In most multiphase abdominal examination each phase is performed with constant scanner parameter settings which are standardized with every CT scanner model as per the set regulations(ICRP) and each phase multiplies the total patient dose (Waszczuk, Guziński, Garcarek, & Sąsiadek, 2018). As a result, the total dose is increased as per the number of phases being performed but the scan parameters remain the same all through the phases for the given CT protocol during the examination. The aim of the researcher was to categorize the scans into a single phase or multiphase where applicable and obtained the respective dosages and compared the variations with the already stipulated guidelines by ICRP/UNSCEAR. The displayed average CTDIvol, DLP and Effective dose post scan which are patient specific were the data that were retrieved from the CT database systems.

The data storage in CT scanner systems can be categorized into three; console storage, advanced view workstation (AVW) and PACs. Console storage is a primary component of the data acquisition systemswithin the CT set up. It has limited storage capacity and only data for a given limit can be stored for a few days then auto deleted, depending on the scanner models. The advance view workstation can act as secondary temporary integrated storage for a short period of time which when the limited storage capacity has been exhausted it has to be reformatted. Picture Archiving and communication systems (PACs) is a medical imaging technology that provides economical storage and convenient access to images from multiple modalities. PACs offers unlimited storage capacity it is currently encouraged in busy hospital set ups since it offers long term storage. PAC systems can be institution specific or machine specific for instance at MTRH there is PAXERA and NEUSOFTPACS respectively. The facilities that were involved in this study have PAC systems installed. The PACS offer a better data protection platform since its access controlled and it can have both physical and virtual servers as backups. Sutton et al has indicated that PACS-based dose audit project is proving to be better tools in patient dose modulations and further optimization of CT doses as compared to DRLs which are viewed as more of compliance tools.

CT dose measurements

CT dose is not measured directly on patients. It is measured using standard phantoms and then the measurements are used to estimate patient dosages via Monte Carlo program. The standard phantom for the adult body is 32 cm and adult head is 16cm in diameter. Pediatrics phantom is 16 cm for the body EC (1999). CT dose is measured and reported through different methods, it can be classified into three broad categories: exposure, absorbed dose, and effective dose. In order to accurately determine a patient dose from a CT scan patient size and radiation output must be considered. Basically CTDI or CTDIvol is thought of as a measure of how CT was performed as opposed to the amount dose a patient received. Exposure: is theamount of radiation at a set point in a known amount of air, measured by using an ionization chamber. The measurement of exposure via the ionization chamber is in coulomb per kilogram (Ckg^{-1}) which was previously measured in roentgen(R)[2]. Absorbed dose: it is also referred as the radiation dose; it is the measures of energy absorbed per mass. It is the appropriate parameter to refer to when quantifying how much dose a patient received in CT. It is measured in gray(Gy).Effective dose: the effective dose is the

measure of radiation calculated with the radio sensitivity of specific organs taken into account. It also known as equivalent dose and it is measured in Sievert (Sv).

The commonly encountered dose metrics in CT scan are CT dose index(CTDI), CTDIvol, Dose length product(DLP) and Size Specific dose estimate $(SDDE)^2$.CTDI is the standardized measure of dose output and it is best used to compare CT scanners. It is measured in mGy and it is not a measure of absorbed dose or effective dose. $CTDI_{vol}$ is a CT dose index that measures radiation per slice of tissue using a reference phantom only taking into account the scanner output and therefore not a measure of absorbed or effective dose. Dose length product (DLP) (mGy*cm) is the product of the $CTDI_{vol}$ and scan length. DLP factors inthe length of the scan to show overall dose output and does not take into account the size of the patient and
also is not a measure of absorbed dose or effective dose.It is measured in (mGy*cm). Size specific dose estimate$(SDDE)^2$: it is the measure of absorbed dose but not effective dose. And it takes into account the patient's size, it is measured in mGy.

According to the EC the major dose indices used when measuring dosages are the namely; CTDI, $CTDI_W$, $CTDI_{vol}$, DLP, Effective dose EC (1999). Theoretically CT dose index (CTDI) is a measure of dose from single slice irradiation, is defined as the integral along a line parallel to the axis of rotation (z) of the dose profile, D(z), divided by the nominal slice thickness, t, given(Tsai, Tung, Huang, & Wan, 2003) by the formula;

$$CTDI_{\infty} = \frac{1}{t}\int_{-\infty}^{\infty} D1(z)dz.$$

Fig. 1 Formula for CTDI calculation

When measuring the dose radiation, CTDI being the key parameter is obtained from measurement of dose, D(z), along the z-axis made in air using a special pencil-shaped ionization chamber 100mm in length and plastic anthropometrics dosimetry phantoms of standard size diameters (16 and 32). Measurements of CTDI in air (CTDI100, air) and in the cylindrical polymethy lmethylacrylate (PMMA) phantoms (CTDI100, phantom) of diameter 32 cm (body) was appropriated foradult abdominal CT scan as recommended by EC guidelines based on the typical patient and exposure related parameters for this study (EC 1999) (Meghzifene et al.,2010).

In this study, CTDI among other parameters was to be obtained from the displayed CT parameters post exposure specific to the patient for CT Abdominal examination from the various CT scanners of the respective hospitals under the study. Currently Modern CT equipment have advanced dosimetry software programs (e.g. Monte Carlo) and technical capacity to perform dose modulation according to patient size, height or weight which might provide homogenous and optimal effective dosages which are patient specific(IAEA 2007). Hence there are studies being done to compare whether Size Specific Dose Estimates can be more accurate in estimating patient dosages (AAPM 2014).

The CT scanners under the study have their valid licensure which is renewed annually by the Kenya Nuclear Regulatory Authority (KNRA). KNRA inspects and ensures the CT machines are calibrated to the required legal safe dosimetry standards as required by law and in keeping with the ICRP, IAEA and UNSCEAR.

Determination of reference dosages

Advances in CT technology has made it possible to carry out digitally dose modulation specific to the patient through standardized software applications installed in the modern scanners and thus display average optimal effective dosage that are patient specific. The CT machines under the study were of current technology and hence the researcher collected the displayed average $CTDI_{vol}$, DLP of post exposure scan of each patient examined and for each specific CT machine for every hospital and estimated the dosages and

come up with their mean distributions for comparisons with the international DRLs.

Data Analysis

The data analysis process involved cleaning, classification, coding, and tabulation of collected data hence amenable for analysis. The data collected from MTRH, Eldoret Hospital, Mediheal Hospital, St. Luke's Hospital was de-identified and recorded on an access database which was password protected so as to maintain confidentiality. Descriptive statistics of the dose distribution findings across CT scanners surveyed was used to determine mean, minimum and maximum values. Mean values for each facility was calculated, and then rounded 75th percentiles of DLP and $CTDI_{vol}$ was used as a basis for DRLs. To compare doses between scanners of different numbers of detectors, Student's t-test and one-way ANOVA test was used to compare two and more than two groups of scanners, respectively.

The analyzed data included departmental CT protocols routinely applied to average-sized adult patients (weighing between 60 and 80 kg) for abdominal examination, included scanning parameters, such as detector collimation, slice thickness, tube current, tube potential, tube rotation time, scan range and pitch.
Radiation dose recordings, included the displayed CT dose index volume ($CTDI_{vol}$) and dose length product (DLP). Data was imported into STATA version 16 for analysis.

Means and their corresponding deviations for Volumetric CT-dose index ($CTDI_{vol}$), dose length product (DLP) and scan length from the scans from each facility was calculated and presented in a table. Medians and their corresponding interquartile ranges were calculated for each facility.

The averages were calculated for Volumetric CT-dose index ($CTDI_{vol}$), dose length product (DLP) and scan length from each facility and compared with international DRLs through construction of confidence intervals. Also, comparison was made between different models of CT scanners for the respective facilities under survey. The results were presented in tables and figures and recommendations communicated back to each facility for comparisons and encouraged to take appropriate actions where necessary.

Ethical Consideration

Ethical review and approval were obtained from Moi University Institutional Research and Ethics Committee (MU-IREC) and NACOSTI for licensure before proceeding to the field. Permission to carry out the research at Moi Referral and Teaching Hospital, Eldoret Hospital, Mediheal and St. Luke's hospital was sought and duly provided. Since there is no direct involvement of patients there were no consent forms to be addressed.

RESULTS

A total of 700 Abdominal CT scan were reviewed in this study and included in the analysis. This represented 83 % of the total sample size of 842 as had been calculated. A target of 100 % could not be achieved at the time of data collection due to routine CT maintenance at the respective study sites. Table 2 shows the characteristics of the reviewed scans as well as the characteristics for the participants whose CT scan were reviewed. We observed that 66.4% of the reviewed scans were from public facilities and Siemens was the most common scan model 70%. Majority of the scan 82.3%were from CT scan that were manufactured as from 2016. Almost all the scan had a contrast administered 96.8%.The mean CTDI was 8.1mGy and the mean DLP values was 1699.1 mGy.cm.

The mean age of the participants was 52 years and 53% were females. For almost all the patients 98 % whose CT scans were reviewed the positioning was H-SP.

TABLE II: Descriptive

Variable	Freq (%)
Type of Facility	
Private	249 (35.6%)
Public	451 (64.4%)
Scanmodel	
Neusoft	72 (10.3%)
Philips	138 (19.7%)
Siemens	490 (70.0%)
Year of manufacture	
Missing	19
2007	19 (2.8%)
2013	75 (11.0%)
2014	27 (4.0%)
2016	316 (46.4%)
2017	189 (27.8%)
2018	55 (8.1%)
Contrast administered	
Missing	13
Contrast	665 (96.8%)
Non-contrast	22 (3.2%)
Patient Age	
Missing	3
Mean (SD)	52.227 (17.668)
Range	14.000 – 101.000
Patient Gender	
Female	376 (53.7%)
Male	324 (46.3%)
Patient positioning	
N-Miss	2
Feet First Supine	13 (1.9%)
H-SP	685 (98.1%)

The mean CTDI was 8.1mGy and the mean DLP values was 1699.1 mGy.cm as shown in Table below

TABLE III: CTDI and DLP Values

	Median (IQR)	Mean (Std)	Range
Total DLP(mGy.cm)	1465.0 (1019.5, 2213.7)	1699.1 (1053.1)	0.0 – 7318.2
CTDI vol (mGy)	6.1 (4.6, 8.4)	8.1 (22.2)	0.0 – 549.3

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TABLE IV: To Compare Dose Reference Levels for The Adult Abdominal CT Scan Modality at MTRH, Eldoret Hospital, St. Luke's Hospital and Mediheal Hospital in Reference to The International Drls

NATIONAL DRLS FOR COMPUTED TOMOGRAPHY	Protocol	Scan region / technique	CTDI vol per sequence (mGy)	DLP per complete examination (mGy.cm)
UK(2019)	Abdomen	All sequences	14	910
	Abdomen and pelvis	All sequences	15	745
Japan DRLs 2020 for Adult CT	Abdomen and pelvis	All sequences	18	880
The Egyptian DRLs	Abdomen-pelvis	All sequences	31	1325
Ghana, Kenya, Namibia and Senegal	Abdomen	All sequences	15.7	737

TABLE V

Country	CTDI(mGy)		DLP(mGy.cm)	
	reference value	Proportion >Ref	reference value	Proportion >Ref
UK	15	18 (2.6%)	910	568 (81.1%)
Japan	18	10 (1.5%)	880	580 (82.9%)
Egypt	31	5 (0.7%)	1325	401 (57.3%)
Ghana / Kenya / Namibia/ Senegal	15.7	14 (2.0%)	737	608 (86.9%)

DISCUSSION

A total of 700 adult patients who underwent abdominal CT scan from the respective hospitals were enrolled in the study. Participant mean age was 52.227 years and ranged from 18 years to 101 years, with more than 53% of the reported examinations belonging to the female patients. The average age of the population gave the impression that currently CT abdominal examination in private and public hospitals in Eldoret is mostly performed on patients that are more advanced in age. Majority of the existing population are young and female, with significant exposure to the probability of radiation risk. Similar finding was also described by Korir et al., (2016) in a study done in Kenya. Likewise, RakshaErem et al. (2022) reported similar mean age in patients' examinations with an average age of 52 years.

Majority of the CT scans were Siemens machines. In the work by (Nikièma et al., 2016) on CT scan model characteristics in Sub-Saharan Africa, Siemens model were reported as the popular machines in the region. The earliest CT scan year of manufacturer was 2007 and the most recent year of manufactures for a CT scan were between 2016 to 2018. This suggests that most of the installation of CT scan across the public and private hospital have been made in recent years. Similar observation were made by (Uushona et al., 2022) who suggested that the number of CT scanners in direct medical use in Kenya increased by over 80 % in the past decade (2012-2019). The overall increase in the number of CT scans between 2016 and 2018 can, to a large extent, be attributed to the MES, a public-private partnership project (PPP) introduced in 2016, that has equally resulted in availability of more imaging modalities in the public sector. Greater investment by the private sector has also played a role in the surge of CT scans in the country (Gathuru et al., 2021).

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A. Mean CTDI(w) and DLP values for adult abdominal CT examination

The findings demonstrated that average $CTDI_{vol}$ and DLP values for abdominal CT were 8.1 mGy and 1699.1 mGy.cm respectively. The $CTDI_{vol}$ was higher than values observed by Wambani et al., (2010). The reason for this difference may in part be explained by the different methods used. Our results were calculated using measured dose values from dosimetry phantom and the average number of slices done for an average adult patient at each facility. The dose variations in the measured values are also associated with diverse device protocols, different standard examination techniques, device performance, equipment age and also maintenance and service conditions (Smith-bindman et al., 2019), which could explain the difference in measured valued.

This findings of the study also contradict a much more recent study conducted by Korir et al. (2016) in Kenya that reported lower values. The results can be attributed to study methodology, more so the use of Philips CT model as opposed to our study that three model of Philips, Siemens and neusoft. The use of Scanners manufactured by a single company (Philips) in the former study, may have led to substantial homogeneity in the radiation outputs owing to the similar technology and protocol used. The high calculated measured values may also be attributed to the higher exposure factors used and to the possible presence of longer than necessary scan lengths (Adam, 2016). Our study findings were in support of the high average mean values reported for abdominal CT scan at KNH (Musila, 2009).

B. Comparison of dose reference levels for the adult abdominal CT scan modality at MTRH, EldoretHospital, St. Luke's Hospital and Medi heal Hospital in reference to the international DRLs

As $CTDI_{vol}$ and DLP are standard parameters computed for each examination on all modern scanners, they represent a readily available resource for ongoing comparative quality assurance at local, regional, national and international levels.

The findings revealed that the average volume $CTDI_{vol}$ for the current study was lower or higher than the reference countries by less than 3%. CTDI average volume is greater than UK as a reference country by %. The findings of this study were compared with a similar survey on patient dose levels in four African countries of Kenya, Ghana, Senegal and Namibia (Uushona et al., 2022). In the survey, the regional DRL ($CTDI_{vol}$ and DLP) reported for abdomen CT was 10% greater than the CTDI values for UK. This result is also congruent with the high rate of CTDI demonstrated in previous developing studies when compared against international DRLS of European countries (Tobi et al., 2021; Toori et al., 2015; Yurt et al., 2020). A number of factors could account for the variations in the DRLs in the study and international DRLs. These may include the performance of CT equipment, differences in departmental protocol and practice, among other issues.

The findings also indicated that average volume CTDI for the current study was lower than the reference countries of Japan, Egypt, Ghana, Kenya, Namibia and Senegal by between 0.7 to 2%. This implies that CTDI values for abdominal examinations in the current study are significantly lower than those from reference countries. Lower CTDI values in the study in comparison to CTDI values from reference values can be linked to fundamental CT scan parameters (tube voltage, mean tube current, rotation time, tube current–time product, beam width, pitch factor and number of channels) which have been shown to contribute to differences in the radiation dose reference levels.

However, in the current study these CT scan parameters were not analyzed. Shirazu et al. (2017) reported that the differences between the national effective doses reference values and international dose reference values was significant. In a study by Jafari et al. (2020) DRLs for CT scan of chest and abdomen-pelvis showed small differences with international DRLs leading to the conclusion DRLs is a local area dependent

quantity which is influenced by parameters discussed in the above sections.

The findings showed that DLPs values are significantly lower than international DLPs. The DLP values in this study were approximately lower than and comparable with reference countries by over 50%. One probable reason for the relatively low or lower DLP values than those reported in reference studies is the use of standardized protocols. Furthermore, the scanners used in the current study were largely from different manufacturers, which may lead to substantial heterogeneity in the radiation outputs owing to the different technology and protocol used. Similar results were reported on studies that examined DLP values for abdomen CT examination against international DRLs values (Awad et al., 2020; Garba et al., 2020).

CONCLUSIONS

The median for the Total DLP and for the $CTDI_{vol}$ significantly higher in the public facility, Contrast CT and in Neusoft model CT machine

The LDRLs values were markedly lower than the regional and the international values.

RECOMMENDATIONS

It is recommended that this reference dose be temporarily considered as standard dose for optimization protocols until further studies are conducted and information on all adult abdominal CT examinations collected.

STUDY LIMITATION

This study was conducted in 4 leading hospitals in Eldoret town hence may not be a representative of the general Uasin gishu population. Due to heterogeneity of the machines results may not be generalizable to other institutions with different scanners and protocols.

Radiation doses were obtained directly from various CT machines displays. The number is an estimate and not a direct measure of amount of radiation delivered to tissues. However, this methodology has been used in prior studies and is accepted as an appropriate method by which compare radiation doses across institution and scan types.

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i) Conflict of Interest: The authors declare no conflict of interest in this study

REFERENCES

1. Adam, E. A. S. (2016). Estimation of Patient Dose in Abdominal CT Examinations in some Sudanese hospitals. Sudan Academy of Sciences.
2. Ahmed Meghzifene, David R. Dance, Donald McLeana, Hans-Michael Kramer (2010). Dosimetry in diagnostic radiology.
3. International Atomic Energy Agency Dosimetry in diagnostic radiology: an international code of practice**.** IAEA, Vienna 2007 http://wwwpub.iaea.org/MTCD/publications/PDF/TRS457_web.pdf
4. Fingerle, A. A., & Noël, P. B. (2018). Dose reduction in abdominal CT: The road to submillisievert

imaging. European Radiology, 28(7), 2743–2744. https://doi.org/10.1007/s00330-018-5397-z

5. Korir, G. K., Wambani, J. S., Korir, I. K., Tries, M., & Kidali, M. M. (2013). Frequency and collective dose of medical procedures in Kenya. Health Physics, 105(6), 522–533.
6. Mazloumi, M., Gompel, G. Van, Kerseman, V., Me, J. de, & Buls, N. (2021). The presence of contrast agent increases organ radiation dose in contrast-enhanced CT. European Radiology, 31(2), 7540–7549.
7. Masjedi, H., Hosein, M., Neda, Z., Siahpoush, K., Kazem, S., & Ratki, R. (2019). European trends in radiology : investigating factors affecting the number of examinations and the effective dose. La Radiologia Medica, 21(3), 1–10. https://doi.org/10.1007/s11547-019-01109-6
8. Little, M. P., Hoel, D. G., Molitor, J., Boice, J. D., Wakeforde, R., & Muirhead, C. R. (2008). New models for evaluation of radiation-induced lifetime cancer risk and its uncertainty employed in the UNSCEAR 2006 report. Radiation Research, 169(6), 660–676. https://doi.org/10.1667/RR1091.1
9. Mayo, J. R., Aldrich, J., & Müller, N. L. (2003). Radiation exposure at chest CT: A statement of the fleischner society. Radiology, 228(1), 15–21. https://doi.org/10.1148/radiol.2281020874
10. Waszczuk, Ł., Guziński, M., M., Garcarek, J., & S?siadek, M. (2018). Triple-phase abdomen and pelvis computed tomography: Standard unenhanced phase can be replaced with reduced-dose scan. Polish Journal of Radiology, 83, e166–e170. https://doi.org/10.5114/pjr.2018.75682{Bibliography}