**ABSTRACT**

The demand for abdominal Computed Tomography (CT) scans has dramatically increased over the years due to its higher sensitivity in ruling out a wide range of medical conditions as compared to other imaging modalities. However, this patronage is associated with high effective dose and hence attributable to the risk of radiation-induced injuries. Establishing an acceptable radiation dose level and designing a protocol of maintaining dose level within that range is a sure optimization practice that is recommended by most national and international radiation monitoring bodies. The study aims to assess the average radiation dose received by patients undergoing abdominal CT examinations in Radiology unit of AKTH Kano, Nigeria. Dose survey of 100 adult abdominal CT scans in Radiology department of AKTH from June-October 2018. CTDIvol and DLP were simply obtained from the CT machine as displayed on the console and recorded into an adapted IAEA survey form. Effective dose was estimated by multiplying DLP by the conversion factor, k-value for abdomen (0.015mSv/mGy.cm). A total of 100 patient’s radiation dose summary comprising 57 (57%) of females and 43 (43%) males with a mean age of 46 years. Determined 75th percentile CTDIvol, DLP and effective doses for abdominal CT were found to be 12 mGy, 2225.25 mGy.cm and 33.38 mSv respectively. The CTDIvol value was lower than most local and international established studies. The DLP and effective doses of the present study were significantly higher than other studies and calls for review of existing protocol to optimize practice.

Keywords: Abdominal CT, DRL, Effective dose,

**INTRODUCTION**

Rapid adaptation of Computed Tomography (CT) in clinical practice increased over the years compared to all other diagnostic imaging modalities due to the advent of multi-slice CT (MSCT) (Zira et al., 2017). Currently, CT has the advantage of acquiring image of the entire abdomen and pelvis in a single comprehensive study. The sensitivity of CT in detecting intra-abdominal injury exceeds 90% (Webb et al., 2015). With improvements in detector technology, specialized multiphasic imaging is frequently used for studying the liver, pancreas, and kidneys as well as in many abdominal CT angiography (CTA) protocols (Romans 2011). These protocols are useful diagnostic and surgical planning tools with great reduction in invasiveness and cost. Images are acquired faster than the conventional catheter angiography (Webb et al., 2015). The assessment of the intramural and extra-intestinal components of gastro-intestinal are better demonstrated with the MSCT (Webb et al., 2015). The demonstration of direct tumor extension to intra-abdominal organs and distant metastases, especially to the liver. The staging of gastric and colon carcinoma, in planning and managing treatment, and in detecting tumor recurrence are some of the remarkable capabilities of MDCT (Eisenberg & Johnson, 2016). All these capabilities make excessive doses in CT not readily identified through image quality effects as in conventional radiography. Obviously, despite all these remarkable capabilities and accurate outcome in diagnostic radiology, CT directly comes with higher radiation doses to patients (Khorsavi et al., 2014). Hence, the risk of carcinogenesis and other forms of radiation sickness is increased (Foley et al., 2012).
This is a retrospective study that was carried out in the CT suit of Radiology Department of Aminu Kano Teaching Hospital (AKTH), Kano State, Northwest Nigeria from June to October 2018. Only adult patients’ radiation dose data that are 18 years and above and referred for abdominal CT-scan during the period of study were recruited. Incomplete radiation dose summary for any patient was excluded. Purposive sampling method was adopted. A total of one hundred (100) patients radiation data were recruited. Ethical approval to conduct the study was obtained. The CT scanner installed at the study site is a 160-slice Aquilon Toshiba with 2.7 Al eq. inherent filtration, maximum tube voltage of 140 kVp, maximum tube current of 400mA, 512×512 reconstruction matrices, 203×243×107cm gantry size and 78cm gantry opening. Helical scan mode is used for image acquisition with a slice thickness of 0.5×40 mm and tube rotation time of 0.5 s were used all through the scans. Patients’ demographic information and clinical indication for the study were recorded. Scan parameters: kV, mA, scan length, pitch, FOV, scan time, slice thickness, CTDIvol and total DLP values displayed on the console for each patient series were recorded on an adapted IAEA survey form (Nwodo et al., 2018). The mAs value was simply determined by multiplying the mA value with a fixed tube rotation time of 0.5s. Effective dose was calculated by multiplying a conversion factor called k-factor by the DLP value for each patient series. The k-factor is a normalized coefficient found in the European guideline (Nwodo et al., 2018). The k-factor for abdomen is 0.015mSv/mGy.cm. Minimum, maximum and Mean±SD values for CTDIvol, DLP and effective dose were estimated and tabulated. The 25th, 50th and 75th percentiles for CTDIvol, DLP and effective dose were also determined and tabulated. The 25th, 50th and 75th percentiles were used to compare with a similar work conducted in Nigeria. The 75th percentile values were used to compare with European commission (EC) recommendations and other established works.

RESULTS
A total of 100 patient’s radiation dose summary were recruited into the study comprising of (57) 57% females and (43) 43% males. Their age ranged from 18-83 years with a mean age of 46 years. Commonly requested abdominal CT were routine abdomen (62%) and CT urography (CTU) (32%), while the least examinations were Colonoscopy and CT angiography (CTA) with 2% each. The range and mean ±SD of scan parameters were determined. Tube voltages ranged from 100 - 120 kVp, pitch of 1mm, tube current-time product ranged from 85-220 mAs, with mean± standard deviation (SD) of 166±48 mAs, field of view (FOV) ranged from 206-525 mm with mean±SD of 355±46.8 mm and the scan length ranged from 33-58 cm with mean±SD of 43±5 cm. The minimum and maximum CTDIvol for abdominal CT was found to be 2mGy and 20mGy respectively with a mean bb±SD of 8.7±4.5mGy.

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The minimum and maximum DLP for abdominal CT was determined to be 506 mGy.cm and 496 mGy.cm respectively with a mean ± SD of 1795.1 ± 1086.9 mGy.cm. The minimum and maximum effective dose was determined to be 8 mSv and 75 mSv respectively with mean ± SD of 26.9 ± 16.3 mSv. The determined 25th, 50th and 75th percentile CTDI<sub>vol</sub>, DLP and effective doses were determined and presented in Table 1.

### Table 1: Percentile distribution of radiation doses from Abdominal CT.

<table>
<thead>
<tr>
<th>Percentile</th>
<th>CTDI&lt;sub&gt;vol&lt;/sub&gt; (mGy)</th>
<th>DLP (mGy.cm)</th>
<th>Effective Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>5</td>
<td>990.75</td>
<td>14.86</td>
</tr>
<tr>
<td>50&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>7</td>
<td>1449.5</td>
<td>21.74</td>
</tr>
<tr>
<td>75&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>12</td>
<td>2225.25</td>
<td>33.38</td>
</tr>
</tbody>
</table>

The determined 75th percentiles of CTDI<sub>vol</sub>, DLP (DRL) and effective dose values of the present study were compared with other established DRLs in Nigeria (Table 2) and other countries (Table 3).

### Table 2: Comparison of Radiation Dose (DRLs and effective dose) between Present Study and other reported works in Nigeria.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>CTDI&lt;sub&gt;vol&lt;/sub&gt; (mGy)</td>
<td>12</td>
<td>37.9</td>
<td>15</td>
<td>19.20</td>
<td>20</td>
</tr>
<tr>
<td>DLP (mGy.cm)</td>
<td>2225.25</td>
<td>1902</td>
<td>757</td>
<td>1290</td>
<td>1486</td>
</tr>
<tr>
<td>EFFECTIVE DOSE (mSv)</td>
<td>33.38</td>
<td>22.5</td>
<td>11.9</td>
<td>19.35</td>
<td>22.29</td>
</tr>
</tbody>
</table>

### Table 3: Comparison of radiation dose values (DRLs and effective dose) from this study, Other countries and EC recommendations.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>CTDI (mGy)</td>
<td>12</td>
<td>35</td>
<td>13</td>
<td>15</td>
<td>30.8</td>
<td>15</td>
<td>13.71</td>
</tr>
<tr>
<td>DLP (mGy.cm)</td>
<td>2225.25</td>
<td>780</td>
<td>1120</td>
<td>1800</td>
<td>1180.5</td>
<td>716</td>
<td>2336.4</td>
</tr>
<tr>
<td>EFFECTIVE DOSE (mSv)</td>
<td>33.38</td>
<td>11.7</td>
<td>16.8</td>
<td>27</td>
<td>17.7</td>
<td>10.74</td>
<td>35.7</td>
</tr>
</tbody>
</table>

An independent sample t-test was done to check if there’s any statistical significant difference between the radiation dose with sex. However, no statistically significant difference was established in CTDI<sub>vol</sub>, DLP and effective dose among sex (p>0.05).

The mean scan length from the present study (43 cm) was compared with similar works reported in UK and the National Radiological Protection Board (NRPB) (Abdulkadir et al., 2016) (Figure 1). Furthermore, estimated 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles CTDI<sub>vol</sub>, DLP and effective dose values from the present study were compared with the works of Ekpo et al., (2018) who proposed a national DRL for Nigeria (Figure 2, 3 & 4 respectively).
Figure 1: Comparison between scan length from this study, UK and National Radiological Protection Board (NRPB) (Abdulkadir et al., 2016)

Figure 2: Comparison between 25th, 50th and 75th percentiles CTDI\textsubscript{vol} from this study and that of the proposed national DRL. (Ekpo et al., 2018)
Figure 3: Comparison between 25th, 50th and 75th percentiles DLP from this study and that of the proposed national DRL. (Ekpo et al, 2018)

Figure 4: Comparison between 25th, 50th and 75th percentiles effective dose from this study and that of the proposed national DRL. (Ekpo et al, 2018)
DISCUSSION

A maximum tube voltage of 120 kVp was determined in the present study. This is in line with similar works of Moifo et al., in 2017. However, Ekpo et al., in (2018) reported a higher value of maximum tube voltage of 140 kVp. Regarding tube current-time, the 166 mAs obtained in the present is far less than most similar works reported in the literature (Zira et al., 2017; Abdulqadir et al., 2016; Nwodo et al., 2018; Ekpo et al., 2018; Ogbole & Obed, 2014). Treier et al., (2010) reported 224 mAs, Sadri et al., (2013) reported 179 mAs, Khosravi et al., (2014) reported 190 mAs, Abdulkadir, (2015) reported 200 mAs, Moifo et al., (2017) reported 246 mAs and Ekpo et al., (2018) reported as high as 300 mAs for image acquisition. The variation in these exposure factors between the present and other study may obviously be due to equipment and protocol differences. While the present study was a single centre study, Ekpo et al., (2018) adopted a multi-centre approach, thus incorporating other protocols from older machines as against the present study where the equipment was simply installed just 4 years ago. In addition, selection kVp and mAs in the present study site were performed solely by Radiographers and were based on patients’ size, age, anatomical region and clinical indication. This may be suggesting a commendable level of optimization in the study site, thus, a measure canvassed by the NRPB, ICRP and EC (Zira et al., 2017; Foley et al., 2012; Abdulqadir et al., 2016; Ekpo et al., 2018; Ogbole and Obed, 2014, Sadri et al., 2013; Abdulkadir, 2015). Similarly, estimated mean scan length of the present study is found to be slightly higher than UK and NRPB recommendations (Abdulkadir et al., 2016). The slight variation may be attributed to body habitus, race and geographical differences between British and Nigerian population.

A maximum pitch factor of 1mm was the pitch setting during helical acquisition of all abdominal CT scans in the study. This is similar with the work of Moifo et al., (2017) but lower than the works of Treier et al., (2010); Sadri et al., (2013) and Abdulkadir, (2015) where they reported a pitch value of 1.38mm, 1.8mm and 1.5mm respectively. Pitch in multi-slice CT is inversely proportional to radiation dose (Abdulkadir, 2015). The use of lower pitch at the present study site may be attributable to local protocol. Optimizing exposure factors will definitely affect image quality, and in an attempt to compensate for this may have warranted the setting of lower pitch value.

The established local DRL in the present study was found to be lower than most studies carried out in the different regions across the country (Northwestern Nigeria, North-central Nigeria, North-eastern Nigeria and even national survey). The present study’s CTDIvol from this study was found to be lower than all studies that was carried out in Northwestern Nigeria, North-central Nigeria, North-eastern Nigeria and even a national survey (table 3). The lower value may be attributed to the age of CT equipment. The equipment was recently installed; in the year 2015 and couple with the local protocol that optimized exposure factors. Variations exists in DLP among studies carried out across the different geo-political reasons of Nigeria (Zira et al., 2017; Abdulqadir et al., 2016; Nwodo et al., 2018; Ekpo et al., 2018; Ogbole and Obed, 2014). Similarly, DLP from the present study was higher than most of these studies. Abdulkadir et al., (2016) in North-central Nigeria, Zira et al., (2017) in North-eastern Nigeria, Ogbole & Obed, (2014) in South-eastern and Ekpo et al., (2018) (national survey) reported DLPs of 757mGy.cm, 1290mGy.cm, 1902mGy.cm and 1486mGy.cm respectively Nigeria (Zira et al., 2017; Abdulqadir et al., 2016; Nwodo et al., 2018; Ekpo et al., 2018; Ogbole and Obed, 2014). Since, these studies were carried out in different geo-political regions across the country and DLP is a function of length of anatomical region of interest, a possible explanation to these may be the differences in body habitus in each geo-political zone since each zone is dominantly populated by a particular tribe or ethnic group. Furthermore, differences in exposure parameters, radiographic protocol and even calibration of equipment could account for these variations. Hence, the need for standardization of practice is emphasized so as to maximize the potential of optimization is practice.

The estimated effective dose from this study was determined to be 33.38mSv and found to be higher than other studies conducted in the country (Zira et al., 2017; Nwodo et al., 2018; Ogbole and Obed, 2014; Abdulkadir, 2015). This is expected because of the high DLP obtained in the current study since it is derived from the DLP. Nonetheless, the difference is significant and calls for optimization. Differences in practices (protocols) and advancements in technology varies from one country to another and even among centers. Hence, a country or center’s DRL cannot be a good factor for generalization.
This justifies the recommendation by the Institute of Physicist and Engineers in Medicine (IPEM) 2004 which states that every country should have or set its DRLs. Therefore, the present study has attempted to establish a local DRL which can form basis for further studies in attempt to establish a National DRL (nDRL) for abdominal CT in Nigeria. Comparison of the 25th, 50th and 75th percentile IDRL values of the present study and the works of Ekpo et al., (2018) who reported a proposed nDRL. The CTIDL of the present study is consistently lower across all the percentiles. However, DLP and effective dose values from the present study were much higher across the percentiles. Possible reasons may be due to lower pitch factor and longer scan lengths observed in the present study. Further comparison of the present study’s DRLs and effective dose with European values indicates that CTIDL from this study was significantly lower to that of the EC recommendations. However, the DLP and effective doses from this study were much higher than that of the EC recommendation and other European countries except a work in India (table 3). The study recommends a review of protocol to optimize scan length and number of phases in image acquisition.

REFERENCES


