Patient doses in CT examinations: A contribution to the establishment of local diagnostic reference levels in CT

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**Authors:** H. Kamoun¹, M. Guerfel², H. Mizouni², M. F. Ben Slimene¹;  
¹centre national de radioprotection, hospital d'enfants/TN, ²service de radiologie, Hopital La Rabta/TN  
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Aims and objectives

Computed tomography (CT) has become the major source of population exposure to diagnostic X-rays [1]. Optimization measures within the modality are crucial to ensure appropriate use and avoidance of unnecessary radiation exposure. CT dose index (CTDI) and dose-length product (DLP) have been proposed as the appropriate dose quantities for the establishment of diagnostic reference levels (DRLs) for optimizing patient exposure[2]. DRLs are currently not available in Tunisia, hence a survey was performed in the department of radiology of Rabta Hospital, Tunis, Tunisia in order to measure radiation doses for CT, compare them with the currently proposed European reference dose values and produce a preliminary set of data for the establishment of local diagnostic reference levels (LDRLs).
Methods and materials

A retrospective and descriptive study, including 1858 CT examinations in adult patients with a standard morphotype realized by multi-detector (64 slices) General Electric CT (GE). Only CT interesting head (n = 814), chest (n = 342), or abdomino-pelvis (n=702) regions were included in this survey. Collected data included patient sex and age; tube voltage and tube current, thickness; number of sections; CTDI and DLP over a period of three months from January 2015 to Mars 2015. CTDIvol in milligray (mGy) is used to express the absorbed radiation dose in a cylindrical shaped phantom for a specific volume slice computed tomography dose index (CTDI), whereas DLP in milligray per centimetre (mGy.cm) is the CTDI volume multiplied by the length of the scan [8]. Descriptive statistics analysis of the dose distribution found across CT scanners surveyed in DLP (mGy.cm) and CTDI vol (mGy) were used to determine mean, minimum and maximum values. All calculations were performed using SPSS 19 version. 75th percentile of DLP and CTDI vol for each site were calculated and used as a basis for LDRLs (Table). These LDRLs were compared to European DRLs. Then mean DLP for 30 scanners chosen per year for different regions (head, chest, or abdomen-pelvis) were calculated and compared to LDRLs.
Results

Introduction:

CT has been reported as being one of the largest sources of medical radiation when compared to other modalities such as plain radiography [1]. Therefore, optimization process should take actions to reduce radiation dose to patients undergoing CT examination to comply with the "As Low As Reasonably Achievable" (ALARA) principle[2]. In medical exposure, diagnostic reference levels (DRL) was introduced to identify situations in which the load of the radiation is beyond current practice patient examination [3]. DRL implemented by European countries to several radiological investigations are a practical tool to promote the assessment of existing protocols by facilitating the comparison of doses from present practice. DRLs were defined by the ICRP in 1996 as being a form of investigation level to do so [4]. They act as a test for identifying situations where patient doses are becoming unusually high and local review of procedures and equipment is required. The pragmatic way, recommended by European Commission, to assess DRL values is to use the third quartile values observed in wide scale surveys of typical doses for common procedures[6,7]. If it is regularly exceeded, this high dose must be justified or reduced through appropriate optimization measures. In Tunisia, we have not yet established our national DRL. The aim of our study was to evaluate our CT practice by comparing the values of 75th percentile radiation doses delivered to our adult patients (CTDI vol, DLP), to European DRL in order to develop our own DRL and judge the need to make corrections to our protocols.

Results:

The comparison between LDRL and European DRL, shows that doses delivered to our patients were within the recommended standards for the brain scan.

There is a moderate exceeding the recommended doses for the thoracic and abdomen-pelvis CT.

Mean DLP values for the thirty exams selected of each region were below the European DRLs: 716 mGy . cm at head CT and 757 mGy.cm at abdomen-pelvis CT but discreetly higher at chest CT; 497 mGy .cm . All of them are below calculated LDRLs.

Discussion:

CT is nowadays the main source of artificial radiation for medical purposes[1]. However it is considered a high radiation dose modality therefore establishment of DRLs is highly recommended [2]. DRLs implemented by European countries to several radiological
investigations are a practical tool to promote the assessment of existing protocols by facilitating the comparison of doses from present practice [4].

In this purpose, every department of radiology should provide an annual dosimetric report [5].artment of radiology should provide an annual dosimetric report [5].

In this study dose measurements on CT scanners involving three routine CT examinations have been performed in order to evaluate their performance and to produce a preliminary set of data for the establishment of LDRL.

CTDI and DLP were recorded for each patient because they are proposed as the appropriate dose quantities for the establishment of DRLs for optimizing patient exposure.

The result obtained in this Research provides a base for LDRLs for adult head ,chest and abdomen-pelvis scan in the hospital.

The comparison of patients doses with other published work reveal that a CT study should use as little radiation dose as possible, while still meeting the image quality needs of the examination and this should be done according to radiation safety principles.

A total of 1858 adult patients participant were included in this study.

Table 1 presents the CTDI vol and the DLP obtained at the hospital which is the dose parameters for routine scan. The table 1 shows 3rd quartile values of DLP respectively for chest, head and AP (650.19 mGy.cm ; 748,76 mGy.cm; 973.39 mGy.cm). It also shows 3rd quartile values of CTDI vol for all the patients in the study as (17.93 mGy ; 36.47 mGy; 18.65 mGy). The LDRLs for this study has been established as the 3rd quartile value of CTDI vol and DLP for all the patients. Table2 shows the comparison of CT scan parameters used in study with European DRLS. It has been observed from the table that doses delivered to our patients were within the recommended standards for the brain scan. It has also been found that there is a moderate exceeding the recommended doses for the thoracic and abdomen -pelvis CT.

The table 2 shows that mean DLP values for the thirty exams selected of each region were below the European DRLs: 716 m Gy . cm at head CT and 757 mGy.cm at abdomen-pelvis CT but discreetly higher at chest CT; 497 mGy.cm . All of them are below calculated LDRLs . The study has established the LDRLs for adult brain, chest and abdomen-pelvis CT in our department .It indicate that there is still a large optimization potential of diagnostic CT examinations .We should implement a monitory and functional radiation safety committee comprising of radiographer and medical physicists for periodic re-audits at short-time .A national survey should also be carried out in Tunisian hospitals to set a National Diagnostic Reference Levels (NDRLs) for examination in CT centers so that radiation doses can be compare and take remedial action without affecting image quality .
Table 1: Descriptive statistic of the dose distribution of the 1858 CT scanners surveyed in DLP and CTDI vol.

<table>
<thead>
<tr>
<th>Exam</th>
<th>Range DLP (mGy.cm)</th>
<th>75eme Percentile DLP (mGy.cm)</th>
<th>75eme Percentile CTDI vol (m Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>116.17-1026.55</td>
<td>650.19</td>
<td>17.93</td>
</tr>
<tr>
<td>Head</td>
<td>172-1619</td>
<td>748.76</td>
<td>36.47</td>
</tr>
<tr>
<td>AP</td>
<td>142.3-3355.37</td>
<td>973.39</td>
<td>18.65</td>
</tr>
</tbody>
</table>

**Fig. 1**: CTDI vol: CT volume index; DLP: dose-length product; AP: abdomen and pelvis. Descriptive statistic of the dose distribution of the 1858 CT scanners surveyed in DLP and CTDI vol.

**References**: Department of Radiology, Rabta Hospital, Tunis, Tunisia 2015.
Table 2: Comparison between mean DLP and LDRLs and between LDRLs and European DRLs.

<table>
<thead>
<tr>
<th>Exam</th>
<th>Mean DLP (mGy.cm)</th>
<th>LDRL DLP (mGy.cm)</th>
<th>European DRL DLP (mGy.cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>497</td>
<td>650.19</td>
<td>475</td>
</tr>
<tr>
<td>Head</td>
<td>716</td>
<td>748.76</td>
<td>1050</td>
</tr>
<tr>
<td>AP</td>
<td>757</td>
<td>973.39</td>
<td>800</td>
</tr>
</tbody>
</table>

CTDI vol. CT volume index; DLP: dose-length product; LDRL: local diagnostic reference level; DRL: diagnostic reference level; AP: abdomen and pelvis.

**Fig. 2:** Comparison between mean DLP and LDRLs and between LDRLs and European DRLs.

**References:** Department of Radiology, Rabta Hospital, Tunis, Tunisia 2015.
**Fig. 3**: Dose length product (DLP) distribution for head CT and local diagnostic reference level.

**References**: Department of Radiology, Rabta Hospital, Tunis, Tunisia 2015.
**Fig. 4:** Dose length product (DLP) distribution for chest CT and local diagnostic reference level (LDRL).

**References:** Department of Radiology, La Rabta Hospital, Tunis, Tunisia 2015.
Fig. 5: CT volume index (CTDI) distribution for chest CT and local diagnostic reference level (LDRL).

References: Department of Radiology, Rabta Hospital, Tunis, Tunisia 2015
Fig. 6: Dose length product (DLP) distribution for abdomen and pelvis CT (AP) and local diagnostic reference level (LDRL).

References: Department of Radiology, Rabta Hospital, Tunis, Tunisia 2015.
Fig. 7: CT volume index (CTDI) distribution for abdomen and pelvis CT (AP) and local diagnostic reference level (LDRL).

References: Department of Radiology, Rabta Hospital, Tunis, Tunisia 2015.
Conclusion

From this study we have established our first DRL, in the department of radiology of Rabta Hospital, Tunis, Tunisia, including current CT examination. These DRL used as an optimization tool for our next practice. A collaboration with other medical imaging departments in Tunisia is recommended to establish Tunisian DRL.
References


