PATIENT DOSES FROM DIAGNOSTIC RADIOLOGY.
PRELIMINARY GUIDANCE DOSE LEVELS IN TUNISIA

L. Ben Omrane, N. Chahed and S. Mtimet
Centre National de Radio-Protection (CNRP)
Hopital d’Enfants, Place Bab Saadoun, 1006 Tunis, Tunisia
e-mail : sadok.mtimet@rns.tn

Abstract

Radiation doses from diagnostic radiology constitute the largest contribution to the collective dose from all man-made sources of radiation. The health care level development in Tunisia results in an increase in the number of X-ray installations, which are functioning until now without any quality assurance program. There is no limit on medical exposure, but the aim is to ensure that the doses are kept even lower as reasonably achievable. Entrance Surface Dose (ESD) is one of the basic dosimetric quantities for measuring the patient dose and hence, an excellent tool for optimization purposes and for comparison with the international reference values. ESD value measurement for a patient is also, an essential component of quality assurance program for individual X-ray radiology departments. But, so far, no attempt has been made in Tunisia to find out the doses delivered to the patient undergoing different X-ray procedures. So, in this study, Entrance Surface Doses were performed for the most common type of X-ray examinations in two big hospitals of the capital city. The main investigated types are : chest PA and LAT, Abdomen, Lumbar spin PA and LAT. Entrance Surface Dose measurements were conducted using thermoluminescent dosimeters (TLDs) calibrated at the CNRP’s SSDL using an X-Ray machine with fully characterized qualities. Before measurements, quality control tests were carried out on each radiological equipment used for the examinations. From this preliminary study of 112 patients, it was deduced that the obtained values were comparable to the internationally recommended guidance levels. These data will be useful for the conduction of a national survey and the formulation of a national guidance dose levels for incorporation in the future regulation concerning the patient protection from medical exposure.

1. Introduction

For the last decade, the appreciable increase in Tunisia in medical practices involving the use of ionizing radiation results from economical and health care level developments. The number of X-ray installations has gone up from 1144 [1] to 2388 [2]. This results in an increase to the collective population dose as X-rays represent the largest man-made source of public exposure to ionizing radiation.

According to the general principles for patient protection as laid down by the International Commission on Radiological Protection [3], the reference doses were introduced as a practical tool to aid in the optimization of patient protection [4, 5].

"Reference doses values for diagnostic medical exposures represent thresholds for the internal investigation of potentially poor practice within radiology department" [6]. These investigation levels can also be used for the purposes of comparison of examination technique or for improving dosimetric performance. These levels are recommended as "guidance doses" which has to be transposed into national law [5].

For conventional radiology, the reference dose levels are expressed as values of Entrance Surface Dose (ESD) with backscatter, per individual radiograph and dose area product per complete examination.

The aim of this work is to assess the entrance surface dose per radiograph for some common examinations in two hospitals, to set the preliminary national guidance dose levels in diagnostic radiology. The patient dose measurements of this study are the first reported work that have been done in Tunisia.
2. Materials and Methods

This work was carried out at the Centre National de Radioprotection (CNRP) of Tunis. Dose measurements were performed in the radiological departments of two big university hospitals in the capital city, for 112 patients and 5 radiological examinations.

2.1. Quality Control of X-ray machines

The quality control (QC) tests for the X-ray equipment used were performed with an X-ray test device (4000 M Victoreen) and several tests tools. These tests include output reproducibility, tube potential and timer accuracy and reproducibility and mAs linearity. The focus size, the beam limiting collimator and the beam perpendicularly were tested. The HVL was also measured at 80 kV. The data were treated by a software, then analysed and reported for all the controlled X-ray installations.

2.2. Selection of patient sample

The objective of the measurements is to obtain an indication of the typical dose that is being delivered to an average adult patient by the procedures and equipment used in a particular facility for the types of examination under study.

To meet this objective, patients were selected so that the mean weight of the sample lies within 5 Kg of 70 Kg [7].

2.3. Dose measurements

Entrance surface dose per radiograph were measured using high sensitivity TLD of LiF:Mg,Cu,P. TLDs were supplied in the form of round disc-shaped pellets of 4.5 mm diameter and 0.9 mm thickness.

These dosimeters were annealed before use and suitably packaged in thin plastic sachets so that they can be stuck directly to the patient's skin at the central axis of the X-ray beam.

For each X-ray room and each dose measurement, the details of the exposure (kV, mAs, …) and the patient data (age, weight, height, thickness, …) were recorded in a form.

2.4. Calibration procedure

The calibrations were carried out at the CNRP's SSDL, using an X-ray machine (Pantak hf160), with tube potential varying from 40 to 160 kV. The tube has a tungsten target angled at 20° and a focus size of 3x3 mm². The exit window is 1 mm Be. Two collimators, additional filters, diaphragm and a monitor chamber are in place.

The radiation measurements free-in air were made using a Farmer NE2571 ionization chamber which was calibrated at the IAEA Laboratory with an uncertainty of 1.5 % (95% confidence level) for the air kerma. An additional filtration of 1 mm Al and 0.1 mm Cu was selected. Four X-ray beam qualities were then fully characterised [8] giving HVL ranging from 3.3 to 5.5 mm Al and tube potential from 70 – 120 kV.

Moreover their high sensitivity, the LiF:Mg,Cu,P present a quick regeneration cycle. The dosimeters had been treated thermally in a programmable oven at 240°C for 15 min followed by a cooling to room temperature. The dosimeter reading were made with a manual reader LTM (FIMEL), monitored by computer, using an adequate thermal cycle.
Due to the constraints imposed by their construction, these dosimeters are energy dependent and have therefore to be calibrated at the energy used. Energy response tests for the TLDs were carried out using the characterized X-ray qualities and the ionisation chamber system. The calibration factor was then deduced from an interpolating curve for the tube potential ranging from 70-120 kV. This method provides a calibration factor for each kVp besides to the effective use of a mean energy response over the diagnostic X-rays.

The calibration was performed in air in terms of air kerma (with backscatter). This one was derived from the American Association of Physicians in Medicine (AAPM) dosimetry protocol [9] for the qualities and the field size used. Before calibration, the TLDs were selected from initialised batch, all with homogeneity (sensitivity variation) within 2% of the mean response. In a previous experiments [10] the linearity and the reproducibility were tested. The dose reading from these TLDs was estimated to be reliable to within ± 5 % (without the energy response).

3. Results and Discussions

Figure 1 illustrate the variation of the calibration factor for the TLDs with the applied tube potential. The generated interpolation curve is used to calculate the ESD for each kVp setting. This methodology could reduce the uncertainty due the energy dependence of the TLDs. In diagnostic radiology, the calibration procedure is generally performed at only one point (kVp), which is the mean of the encountered tube potentials [7 ].

![Graph](image)

**FIG .1. Variation of the calibration factor for LiF:Mg,Cu,P with tube potential setting. The curve represents the interpolation curve from 70-120 kVp.**

Table I shows the minimum, quartile (1st and 3rd), median and maximum values of the entrance surface dose for the common types of radiograph from the measurements conducted in the two hospitals.
Table I: Distribution of the Entrance Surface Dose for adult patients at two hospitals in Tunis

<table>
<thead>
<tr>
<th>Radiograph</th>
<th>Entrance surface dose (mGy)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>1st quartile</td>
<td>Median</td>
<td>3rd quartile</td>
<td>Maximum</td>
</tr>
<tr>
<td>- Chest PA</td>
<td>0.08</td>
<td>0.13</td>
<td>0.18</td>
<td>0.22</td>
<td>0.33</td>
</tr>
<tr>
<td>- Chest Lat</td>
<td>0.41</td>
<td>0.49</td>
<td>0.66</td>
<td>0.86</td>
<td>1.08</td>
</tr>
<tr>
<td>- Abdomen</td>
<td>1.77</td>
<td>3.93</td>
<td>7.07</td>
<td>8.99</td>
<td>13.45</td>
</tr>
<tr>
<td>- Lumbar spine AP</td>
<td>1.22</td>
<td>4.43</td>
<td>6.14</td>
<td>7.85</td>
<td>12.73</td>
</tr>
<tr>
<td>- Lumbar spine Lat</td>
<td>6.15</td>
<td>12.93</td>
<td>19.74</td>
<td>24.40</td>
<td>38.25</td>
</tr>
</tbody>
</table>

Table II presents the preliminary diagnostic guidance dose levels of this study which are established on the basis of the rounded 3rd quartile values for the distribution of the measured ESD presented in Table I. The national reference dose levels of the United Kingdom [7], the recommended reference and guidance dose levels given by the International Atomic Energy Agency [5] and the Commission of the European Communities, CEC [4] are also shown in this table. The comparison indicates a compatibility of all these values. It is observed in this table, that the local hospitals delivered ESD values for the Chest (LAT) examination is lower than the corresponding internationally reference values. This is probably due to the small number of patients selected in this examination type (only 4 patients).

Also, as the local practice doses are comparable to the internationally reference dose values, this is because these measurements were performed in radiological departments of university hospitals, with performing X-ray installations (confirmed by the QC tests) and good trained staff. We are aware, that these conditions (staff and equipment) are not usually satisfied in the small radiological centres. Furthermore, this sample is acceptable in Tunis area, but is not enough for a statistical analysis in a national scale compared to dose assessment conducted by the NRPB [7]. So, a national survey has to be conducted.

Table II: Preliminary results of the diagnostic guidance dose levels compared the reference national doses given by the NRPB [7] or those recommended by the CEC [4] and to the guidance levels of the BSS [5].

<table>
<thead>
<tr>
<th>Radiograph</th>
<th>This work</th>
<th>NRPB</th>
<th>CEC</th>
<th>BSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Chest PA</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>- Chest Lat</td>
<td>0.9</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>- Abdomen</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>- Lumbar spine AP</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>- Lumbar spine Lat</td>
<td>24</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
4. Conclusions

The paper presents here the first patient dose survey in diagnostic radiology in Tunisia according to the international recommendations. The study should therefore be implemented on a national scale and for other types of examinations as an approach to establish the national guidance levels for their incorporation in the previous regulation. This study present also a baseline data of the diagnostic radiology exposure which will be useful in the estimation of the collective dose due to the ionizing radiation and the associated risk for the population.

Acknowledgment

This work was supported by the International Atomic Energy Agency, the World Health Organisation and the "Secretariat d'Etat à la Recherche Scientifique et à la Technologie" in Tunisia, which the authors of this paper gratefully acknowledge.

References

6. Hart, D; Hillier, M C; Wall, B F; Shrimpton, P C and Bungay, D ; Doses to patients from medical X-ray examinations in the UK-1995 Review, NRPB-R289, (1995)
9. American Association of Physicists in Medicine (AAPM) Task Group 61, Ma, C M; Coffey, C W; Dewerd, L A; Liu, C; Nath, R; Seltzer, S M; Seuntjens, J P; AAPM protocol for 40-300 kV X-rays beam dosimetry in Radiotherapy and Radiobiology, Med. Phys; 28 : 868-93, (2001)
10. Ben Omrane, L; Chahed, N; Chehimi, F; Trigui, Y et Mtimet, S; Evaluation d'un dosimètre thermoluminescent de Fluorure de Lithium (LiF: Mg,Cu,P), 6ème Colloque National de Recherche en Physique, Hammamet, (1999)