RADIATION DOSE SURVEY IN CONVENTIONAL PEDIATRIC RADIOLOGY

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ABSTRACT

A survey of some conventional radiographic techniques, Entrance Surface Dose (ESD) and Effective Dose (ED) for pediatrics has been carried out for 811 patients undergoing five different examinations for mobile and conventional (fixed) X ray equipment. For the fixed equipment, the examinations were: abdomen, chest, cervical spine, skull and lumbar spine, for different projections AP, PA and LAT in a total of 432 patients. For the mobile equipment, a similar study was performed for 379 patients and for two examinations: abdomen and chest for the AP projection only. The pediatric hospital was the Instituto Fernandes Figueira (IFF) from Fiocruz (Brazil). For each examination, 4 different age groups 0-1, 1-5, 5-10 and 10-15 years were studied for both types of equipments. Results can be compared for abdomen AP and chest AP only, because were the only kind of examinations performed with both types of equipment. The mean ESD (µGy) and ED (µSv) were calculated using the DoseCal software. For chest examination in AP the ESD for fixed and mobile X ray equipment for the 0-1 age group were 67µGy and 39µGy respectively. For abdomen AP, results were: 242µGy for fixed and 57µGy for mobile equipment. Similarly, the ED values for different types of equipment for chest AP were 12µSv (fixed) and 8µSv (mobile). For abdomen, results were 53µSv and 13µSv (fixed and mobile), respectively. It can be seen that all results for the fixed equipment are systematically higher.

KEYWORDS: Entrance Skin Dose, DoseCal software, Effective Dose, Pediatric Radiology

الملخص:

لقد تم في هذه الدراسة مسح إشعاعي لقياس كل من الجرعة السطحية والجرعة الفعلية للأطفال حريت الدراسة على 811 طفل لخمسة فحوصات مختلفة وهي تشخيص البطن، الصدر، الرأس، والعمود الفقري في اتجاهات أمامي خلفي، وبائي، وشملت الدراسة أجهزة الإشعة
INTRODUCTION

In 1998, the Brazilian Sanitary Surveillance and the Ministry of Health of Brazil published the decree 453\[1\] establishing radiation protection guidelines for diagnostic radiology in medicine and odontology. Among the legal exigencies contained in the decree, it is mandatory the implantation of Quality Assurance Programmes (QAP) in all institutions that use ionising radiations. QAP in general diagnostic radiology have been developed in several countries in the past years, mainly in Europe\[2-5\]. However, the need for special QAP for paediatric patients were first realised early in the 1980s\[6,7\].

There is substantial evidence to suggest that children are more susceptible to the effects of ionizing radiation than adults. As a consequence of the longer life expectation this places an added burden on staff to attain the best possible results every time. Likewise, the probability that there may be late radiation effects is also higher. Exposures to ionizing radiation are dependent on the age at which exposure occurs. Exposure during childhood results in a likely two or three fold increase in lifetime risk for certain detrimental effects, including solid cancers, compared with that in an adult\[8\].

Wide variations in patient doses up to a factor of 100 for radiation exposure of the same projection have been reported in the literature\[9,10\]. Diagnostic Reference dose levels (DRL) provide a framework to reduce this variability\[11-13\]. Variations of dose within a hospital emphasize the importance of QAP so that inconsistencies and errors in technique and equipment can be discovered early and hence reduce the variation in dose to patient. There is
no consensus on the optimal radiographic technique. However, if they were optimised a significant reduction in collective dose could be achieved. A Malaysian study \cite{14} showed that it is possible to achieve much tighter control on patient dose variation demonstrating factor of 5 to 30. It is worth noting that all hospitals in the Malaysian survey carried out a QAP. Reasons for dose variations are very complex and difficult to identify, however, high doses are frequently associated with low kV, high mAs and low filtration. There is considerable evidence \cite{15-22} that substantial reductions in doses are possible without detriment to the patient. Consistently high departmental doses will result in either an acceptable justification for the dose or revisions in technique or equipment to bring radiation doses in line with other reference dose level.

The reasons for dose variation are multifactorial: patient weight, exposure factors, radiological technique, FFD, film-screen speed, equipment type and processing performance \cite{24}. Weight restrictions can minimize the contribution of patient size to the mean dose variability \cite{25}.

The aim of this work was to estimate the Entrance Skin Dose (ESD) and the Effective Dose (ED) for several kinds of exposures of paediatric patients and to compare these results for two different kinds of equipment: fixed and mobile. Several kinds of examination for AP, PA and LAT projections have been investigated. The age intervals considered were 0-1 year, 1-5 years, 5-10 years and 10-15 years.

**MATERIALS AND METHOD**

This study was carried out in the Instituto Fernandes Figueira (IFF) at the pediatric hospital of FIOCRUZ (Brazil). For each patient, the age, sex, weight and technical parameters of exposure (tube voltage, current, time product, SSD) were recorded.

Six X-rays machines were used in this work: one conventional equipment, another one with fluoroscopy and four mobiles. Only films that were considered diagnostic by the radiographer were accepted for this study. This ensured that all dose levels used were representative of diagnostic image. While all radiographs were found to be diagnostically acceptable, major differences in technique were evident reflecting the disparity in experience between staff.

The dose values were obtained with the use of the DoseCal software that provides the ESD as well as the ED. The use of software packages to perform
patient doses is a modern resource in dosimetry and is being widely used in hospitals [24,25]. The calculation of ESD from output measurements and exposure factors is a realistic alternative method to (Thermoluminescent dosimetry) TLD measurement. The software used in this work was specially developed for the evaluation of these doses. It was built at the Radiological Protection Center of Saint George’s’ Hospital, London, and generously donated for the elaboration of this research work. It is a computer-based system by which patient doses can be determined from exposure factors recorded at the time of the examination.

For the DoseCal software, the tube output of all X-rays machines was measured using calibrated ionisation chamber Radcheck Plus X-rays exposure meter. Once the tube potential, the tube current, the exposure time and the focus to skin distance are known, the formula 1 gives the ESD.

\[
\text{ESD} = \frac{\text{Output} \times \left(\frac{\text{kV}}{80}\right)^2 \times \left(\frac{100}{\text{FSD}}\right)^2 \times \text{mAs} \times \text{BSF}}{100 \times \text{mAs} \times \text{FSD}}
\]  

Where \( \text{Output} \) is the output of the X-rays tube in mGy/mAs, at 80kV at a distance of 1m normalised to 10 mAs, \( \text{kV} \) is the tube potential, mAs is the product of the tube current and the exposure time, FSD is the focus to skin distance and BSF is the back scatter factor.

RESULTS AND DISCUSSION
The results of ESD and ED for the different examinations are tabulated according to the age group, and kinds of projections AP, PA and LAT. ESD values were obtained for standard working conditions prior to any correcting action being taken.

Table 1 shows the statistical results of ESD and ED for abdomen and chest in AP projection for the mobile equipment. The minimum, maximum, SD (standard deviation), mean and median, as well as the sample size (number of patients) are displayed. For example, in table 1 (mobile equipment), for chest AP it showed a variation from 1 to 156µGy for the age range from 0-1 years. For the other age intervals similar differences have been reported. For abdomen AP, in the same age interval, results range from 2 to 368 µGy.

Table 1: Values of ESD (µGy) and ED (µSv) for mobile equipment for the AP projections of chest and abdomen.
Table 2 shows the ESD reference levels \[21\] for different ages (newborns, 1 year, 5 years and 10 years). It is somewhat difficult to compare with our results since we have evaluated age ranges and from this range calculated the mean values. However, the reference levels serve as guidance, for the sake of comparison with our results.

Table 2: ESD (µGy), reference levels for AP, PA and LAT projections for chest, skull and abdomen \[21\]

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>0-1</th>
<th>1-5</th>
<th>0-1</th>
<th>1-5</th>
<th>5-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD (µGy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>57</td>
<td>83</td>
<td>39</td>
<td>58</td>
<td>56</td>
</tr>
<tr>
<td>Min</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>First quartile</td>
<td>20</td>
<td>37</td>
<td>20</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Third quartile</td>
<td>61</td>
<td>122</td>
<td>40</td>
<td>72</td>
<td>78</td>
</tr>
<tr>
<td>Max</td>
<td>368</td>
<td>294</td>
<td>156</td>
<td>269</td>
<td>138</td>
</tr>
<tr>
<td>SD</td>
<td>45</td>
<td>48</td>
<td>25</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>Median</td>
<td>30</td>
<td>71</td>
<td>28</td>
<td>38</td>
<td>40</td>
</tr>
<tr>
<td>Sample size</td>
<td>69</td>
<td>37</td>
<td>139</td>
<td>115</td>
<td>19</td>
</tr>
<tr>
<td>ED (µSv)</td>
<td>13</td>
<td>16</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 3 shows the results for abdomen, cervical spine, chest, skull and lumbar spine for AP, PA and LAT projections. Again wide variations have been reported. For abdomen AP in the age interval from 0-1 years the ESD varied from 81 to 900 µGy. For the age range 1-5 years, the ESD for cervical spine AP varied from 36µGy to 1250µGy. Similarly, for the age interval 1-5 years, for chest AP it varied from 17 to 648 µGy. For the same age range and skull AP the variation was from 213 to 1540µGy. For lumbar spine AP, variations ranged from 4 to 1229 µGy. Similarly the results for ED (µSv) presented also a wide variation for all age ranges, Table 4. shows the range of exposure factors, focus-to-skin distance (FSD) and filtration used for each projection in IFF hospital.
Table 3: ESD and ED for several projections in AP, PA and LAT for fixed equipment.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Abdomen AP</th>
<th>Cervical Spine AP</th>
<th>Skull AP</th>
<th>Lumbar Spine AP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESD (µGy)</td>
<td>ED (µSv)</td>
<td></td>
<td>ESD (µGy)</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>** 53**</td>
<td>** 30**</td>
<td>** 365**</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>** 50**</td>
<td>** 21**</td>
<td>** 4**</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>** 51**</td>
<td>** 11**</td>
<td>** 53**</td>
</tr>
<tr>
<td></td>
<td>First quartile</td>
<td>277</td>
<td>** 21**</td>
<td>** 20**</td>
</tr>
<tr>
<td></td>
<td>Third quartile</td>
<td>308</td>
<td>** 21**</td>
<td>** 330**</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>** 27**</td>
<td>** 21**</td>
<td>** 53**</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>** 25**</td>
<td>** 21**</td>
<td>** 53**</td>
</tr>
<tr>
<td></td>
<td>Sample size</td>
<td>7</td>
<td>** 21**</td>
<td>** 53**</td>
</tr>
</tbody>
</table>
Table 4. Range of exposure factors, focus-to-skin distance (FSD) and filtration used for each projection in IFF hospital

<table>
<thead>
<tr>
<th>Examination</th>
<th>Tube potential (kV)</th>
<th>(mAs)</th>
<th>FSD (cm)</th>
<th>Filtration (mm Al)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest PA</td>
<td>55-90</td>
<td>4-16</td>
<td>110-180</td>
<td>2.00-2.50</td>
</tr>
<tr>
<td>Chest LAT</td>
<td>62-100</td>
<td>4-32</td>
<td>100-180</td>
<td></td>
</tr>
<tr>
<td>Skull AP</td>
<td>50-80</td>
<td>16-32</td>
<td>100-150</td>
<td></td>
</tr>
<tr>
<td>Lumbar Spine AP</td>
<td>54-75</td>
<td>16-50</td>
<td>100-150</td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSIONS
A wide distribution of doses has been obtained. The reasons can be: patient size, performance of the equipment and processors, film-screen combination, use of grid and/or training and skill of the staff. It is also accounted for the differences between the radiographic technique used for each equipment associated with the use of either old X-rays generators.
and/or inappropriate radiographic techniques that are poorly suited for paediatric radiology.

The results of this study emphasize the necessity for the adherence to easily followed guidelines for the improvement of training and equipment in paediatric radiology. There is large scope for dose reduction, not necessarily associated with high investments. Dose differences of one order of magnitude, for the same type of examination have been reported.

In our experience, a QAP organized on a central basis can be a useful instrument to reach every hospital, with the aim of improving and optimizing the radiological practice.

ACKNOWLEDGMENTS: we are greatly indebted with: The Radiological Protection Centre-Saint George’s Hospital, London; TWOWS/ICTP; FAPERJ; IRD/CNEN; FIOCRUZ and UFRJ for financial and technical support to this work.

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EVALUATION OF IMMUNOCHROMATOGRAPHIC TEST FOR DIAGNOSIS OF FALCIPARUM MALARIA

By

Ali E. Nasir¹ and Humodi A. Saeed²