Extremity Occupational Dose Estimate in Percutaneous Nephrostomy and Biliary Drainage Interventional Procedure

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Abstract. An estimate of the equivalent dose on the hands of the medical team, who executes examinations of Percutaneous Nephrostomy and Biliary Drainage interventional examinations in a Brazilian hospital, was made. For this estimate TLD100 ring individual monitors were used. They have been calibrated in personal dose equivalent at 0.07 mm depth (Hₚ(0.07)). The doses have been evaluated in each procedure. On average, the dose values measured are higher than the ones obtained in other similar works. Some values surpass the monthly-derived limit for extremities. This work discusses possible causes of these high values and suggests optimisation for radiation protection purposes.

KEYWORDS: Interventional Radiology, extremity dose, TLD, percutaneous nephrostomy, biliary drainage.

1. Introduction

Occupational doses in medical conventional radiology are normally small comparing with other activities. The protection, provided by physical barriers, between radiation beam and staff reduces significantly the occupational exposition. However, in interventional radiology practices, some of the team members must be positioned close to the patient, and consequently to the beam, during the whole procedure or in part of it, increasing their occupational dose. To reduce these doses, the use of individual protection equipment (IPE) is strongly recommended. Lead aprons for thorax and thyroid are obligatory and special glasses and gloves shields are strongly recommended.

Besides the short distance professional-patient, the relatively high examination time, the X rays tube position and the lack of adequate radiation protection training of the staff are important factors that can increase even more the occupational dose. The occupational dose in the geometry where the X rays tube is located above the examination table and the image intensifier below it is always higher than in the opposite way [1]. An ordinary radioprotection error is to put the hand, even partially, in the direct X rays beam [2].

The radiation protection problem in Interventional Radiology is increasing, due to the fast development of this area in the last years, increasing the number of examinations done for each doctor, and consequently his dose. Some deterministic effects have already been identified in hands (epilation) and eyes (cataract) [2].

In this work, the dose received by the professionals’ hands, which execute examinations of Percutaneous Nephrostomy and Biliary Drainage, was measured, using the personal dose equivalent at 0.07 mm depth operational quantity (Hₚ(0.07)).

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2. Materials and Methods

To measure the extremity personal dose equivalent at 0.07 mm depth, ring thermoluminescent dosemeters (TLD) were used. Harshaw LiF:Mg,Ti TLD (TLD 100) was chosen because of its low energy dependence (energy response 30 keV/$^{60}$Co: ~ 1.25), wide linearity range (10 µGy – 1 Gy) and good stability.

The TLD and all other materials and equipments used are from the Thermoluminescent Dosimetry Laboratory (LDT) of the Instituto de Radioproteção e Dosimetria (IRD). The system includes a manual Harshaw 3500 TL reader, a PTW TLDO oven for TLD annealing, TLD rings (Fig. 1), tweezers, storage boxes and stainless steel trays. The handling, storage, annealing and evaluation procedures used are also the ones routinely used in the LDT [3].

The TLD rings have been calibrated in an ISO finger simulator [4] with a standardized $^{60}$Co source beam, calibrated in air kerma. This beam is traceable to the International Metrology System, through the Laboratório Nacional de Metrologia das Radiações Ionizantes, Brazil (LNMRI). The conversion factor from air kerma to $H_p(0.07)$ used is 1.1 mSv/mGy.

The dose received by each used ring $i$, in $H_p(0.07)$, is given by:

$$H_p(0.07) = (L_i - L_{Bkg})\cdot f_n \cdot f_c$$

where:

$L_i$ = reading of TLD used in ring $i$;
$L_{Bkg}$ = mean of readings of TLD used for background irradiation (Bkg) estimate;
$f_n$ = system calibration factor from reading to free air kerma in mGy/nC (evaluated each day);
$f_c$ = $H_p(0.07)$ calibration factor from free air kerma to $H_p(0.07)$ in mSv/mGy.

The expanded uncertainty was calculated for 95% confidence level, taking into account the energy and angular dependence, besides reproducibility of the TLD response in the used system [5].

Figure 1: TLD rings

3. Results and Discussion

A summary of all results obtained is shown on Table 1. The dose range for right and left hands, with the calculated uncertainty ($k=2$), and its mean value are presented. Fig. 2 and 3 show, as histogram, the obtained distribution of dose values, respectively, for Percutaneous Nephrostomy and Biliary Drainage procedures at the studied Brazilian hospital.
Table 1: Summary of dosimetric results.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Rings Location</th>
<th>Dose range (mSv)</th>
<th>Mean Value (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percutaneous Nephrostomy</td>
<td>Right Hand</td>
<td>*M – 34 ± 10</td>
<td>11.21</td>
</tr>
<tr>
<td></td>
<td>Left Hand</td>
<td>1.4 ± 0.4 – 107 ± 31</td>
<td>32.47</td>
</tr>
<tr>
<td>Biliary Drainage</td>
<td>Right Hand</td>
<td>M – 6.3 ± 1.8</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>Left Hand</td>
<td>M – 4.4 ± 1.3</td>
<td>1.82</td>
</tr>
</tbody>
</table>

*M: doses < 0.15mSv (detection limit), considered as zero.

Figure 2: Histogram of doses distribution in Percutaneous Nephrostomy procedure.

Figure 3: Histogram of doses distribution in Biliary Drainage procedure.
In general, the occupational hands’ dose values in the Percutaneous Nephrostomy procedures were larger than the ones in Biliary Drainage. Usually, the dose in the left hand is larger than the one in the right hand, in reason of the physician position during the examination’s execution. The wide range of dose values measured, even for the same type of examination and staff, is predictable due to the high difference not only on the complexity degree of each lesion, leading to modification in the procedure itself, but also differences between the patients. This large dispersion of doses values is founded also in other similar works [1, 6, 7], but with much lower mean doses. This probably is due to the position of the X rays tube and to the poor staff radioprotection training. Differently from this work, the mean dose for Nephrostomy was smaller than for Biliary Drainage procedures.

For Percutaneous Nephrostomy (Fig. 2), 50% of the doses measured were larger than 10 mSv, which is the weekly-derived dose limit for extremities [8] and some of these are on the order of 100 mSv. Assuming that, per year, one physician does almost 100 examinations of this kind at this hospital, the annual dose in his hands could reach values as high as 10 Sv, that is 20 times higher than the annual limit (see Table 2), and in the range of deterministic effects. Considering the mean values of Table 1 and that, in the analyzed hospital, each physician executes about 200 interventionist procedures per year (100 of Percutaneous Nephrostomy and 100 of Biliary Drainage); the annual dose could reach about 3.5 Sv and 1.3 Sv, respectively, on the left and right hand. These numbers show a risk that the dose values received by the professionals exceed the annual dose limit for extremities.

Some causes for those high dose values in the hands were identified. First, the configuration of the fluoroscopic equipment used in the examinations is not the most appropriate. The tube of X rays is on the table, and the image intensifier, below. This arrangement results in a discharge dose in the patient’s proximities and, consequently, the doses in the professionals are higher [2]. The received dose increases with fluoroscopy time. The best protection measure for radiologist’s hands is to avoid placing them direct in the X rays beam. This happened in almost all the cases of dose values above the weekly dose limit. It was possible to identify it, because the image hand appeared in the TV monitor.

### Table 2: Annual Dose Limits [8,9].

<table>
<thead>
<tr>
<th></th>
<th>Classified staff (mSv)</th>
<th>Unclassified/Trainees (mSv)</th>
<th>Public (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body (effective dose)</td>
<td>50</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>(20 mSv/year in 5 years)</td>
<td>(20 mSv/year in 5 years)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Eyes</td>
<td>150</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>Extremities</td>
<td>500</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>Fetus</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

4. Conclusion

The doses evaluation indicates the need of radioprotection optimization of these procedures, to avoid reaching the individual annual dose limit for extremities. During this work, the staff understands the importance of not placing the hand directly in the X rays, and this very simple training has proved to be very efficient in dose reduction. This work confirms the importance of radioprotection knowledge of all the Interventionist Radiology staff. Even with old equipment with bad geometry, the doses have been drastically reduced, only with some minimal information about doses in different conditions.

The second step for optimization of professionals’ hands doses would be the use of radioprotection tools. There exist special gloves that attenuate the X rays beam [7]. The third step would be the change of the equipment (tube on top of the patient’s table and the image intensifier below) that is not the most appropriate, because it increases the professional’s exposure that is positioned in the patient’s
proximities [1]. The high hands’ doses and the uncorrected equipment configuration indicated the need of an evaluation of the doses in the professionals’ lens of the eyes at this hospital.

REFERENCES


