OCCUPATIONAL DOSES IN PEDIATRIC BARIUM MEAL PROCEDURES

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ABSTRACT

Ionizing radiation has become an indispensable tool when it comes to diagnosis and therapy. However, its use should happen in a rational manner, taking into account the risks to which the staff is being exposed. Barium meal (BM), or upper gastrointestinal (GI) studies, using fluoroscopy, are widely used for gastroesophageal reflux disease diagnostic in children and professionals are required to stay inside the examination room to position and immobilize pediatric patients during the procedure. Therefore, it is very important that professionals strictly follow the technical standards of radiation protection. According to the ICRP and the NCRP recommendations, the annual limit equivalent doses for eyes, thyroid and hands are, respectively, 20 mSv, 150 mSv and 500 mSv. Based on those data, the aim of the current study is to estimate the annual equivalent dose for eyes, thyroid and hands of professionals who perform BM procedures in children. This was done using properly package LiF:Mg,Cu,P thermoluminescent dosimeters in 37 procedures; 2 pairs were positioned near each staff´s eye, 2 pairs on each professional´s neck (on and under the lead protector) and 2 pairs on both staff´s hands. The range of the estimative annual equivalent doses, for eyes, thyroid and hands, are, respectively: 14 – 36 mSv, 7 – 22 mSv and 14 – 58 mSv. Only the closest staff to the patient exceeded the annual equivalent doses in the eyes (around 80% higher than the limit set by ICRP). However, the results from this study, for hands and thyroid, compared to similar studies, show higher values. Therefore, the optimization implementation is necessary, so that the radiation levels can be reduced.

1. INTRODUCTION

Fluoroscopy barium meal (BM) studies – upper gastrointestinal (GI) or upper GI series – are an X-ray examination of the esophagus, the stomach and the first part of the small intestine (the duodenum). They are widely used to observe digestive function or to diagnose abnormalities such as: ulcers, tumors, inflammation of the esophagus, stomach and duodenum or gastroesophageal reflux disease (very common in children). In order to anatomy show up on radiographic images, the upper GI tract must be filled with a contrast material – the barium sulfate ($BaSO_4$) [1].

Due to the fact that the procedure applies ionizing radiation, there is a concern because of the higher life expectancy and radiosensitivity of pediatric patients than in adults. Another cause for concern is the irradiation of the staff that accompanies this procedure in the examination room [2].

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This statement is reinforced by Regulla et al., which reported that fluoroscopic procedures, especially the interventional and the GI series, provide lower doses only when compared to computed tomography (CT) scans [3].

There are few studies about occupational doses in pediatric diagnostic fluoroscopy, especially in BM procedures. The only study about this examination was performed by Coakley et al [4]. In this research, equivalent doses in the hands and the thyroid were estimated through the use, in the staff, of $CaSO_4$ thermoluminescent dosimeters (TLDs), during four weeks, resulting in 66 BM studies verified. The results of occupational thyroid and hands doses are, respectively, 1.5 ± 0.4 μSv/procedure and 5.8 ± 1.0 μSv/procedure.

Other study, about occupational doses in brain interventional fluoroscopy, will be used for comparison of results. In this research, equivalent doses in the eyes, hands and the thyroid were estimated through the use of LiF:Mg,Ti TLDs, in 13 pediatric brain angiographies. The results of occupational eyes, thyroid and hands doses (in μSv/procedure) are, respectively, 1.7 ± 0.3; 1.2 ± 0.2 and 1.9 ± 0.3 [5].

Besides these studies, the International Commission on Radiological Protection (ICRP), at the publication 103, to limit stochastic effects, recommends annual equivalent doses for some organs and/or areas, such as the eyes lens and extremities. According to the recommendation, the occupational annual equivalent doses limit for eyes and hands are, respectively, 20 mSv (averaged over defined periods of 5 years, with no single year exceeding 50 mSv) and 500 mSv [6]. The National Council on Radiation Protection and Measurements (NCRP) stablished 300 mSv/year as the occupational thyroid dose limit [7].

Based on those data, the aim of the current study is to estimate the occupational equivalent doses for eyes, thyroid and hands in staffs that perform BM procedures in children.

2. METHODOLOGY

This study was performed at “Pequeno Príncipe Hospital”, one of the largest pediatric hospitals in Brazil. The procedures were carried out with the overcouch fluoroscopy system Philips "Diagnost 93", with total filtration of 2.5 mmAl. The procedures of 37 different patients (from 0 to 16 years old) were studied. The ethics and research committee approved the study and an informed consent was obtained from the staff prior to the procedure.

TLDs LiF:Mg,Cu,P (MCP), circular chips with 4.5 mm diameter and 0.9 mm thickness, from "radPRo International gmBH" (Wermelskirchen, Germany) were used to estimate occupational equivalent doses. The TLD readings were done through the following heating procedure: 100^o C for 10 seconds, 240^o C for 20 seconds and 250^o C for 10 seconds. After the reading, the dosimeters were annealed in an oven at 240^o C for 10 min, in order to restore the material to its original energy state [8].

The dosimeters were encapsulated in pairs in numerically identified plastic envelopes (as is recommended in literature [5]), whose material is the same of intraoral film package, used in dental radiology. This kind of material allows the dosimeter to be sheltered from light and can be used on the patient in the region of the primary beam without causing any image distortion.

The TLDs were calibrated in the fluoroscopy equipment, when the procedures were performed, so that the X-ray beam quality was equivalent to that of the beam used in the examination. The nominal radiography voltage was fixed at 60 kV (the mean voltage applied in pediatric BM procedures) and the mAs values varied from 10 to 40. After the exposure, a linear function (as well as its equation) between the air-kerma (µgy) and the TLD reading was obtained.

In order to estimate the annual equivalent dose (only due to BM procedures), assistants, who remain inside the examination room, at 45 cm and 55 cm distance from the X-rays beam, were investigated. The first staff stays next to the patient's head, administering the barium sulfate during the procedure and the second one stays near the patient's legs for immobilization. In each staff, MCP TLDs, properly encapsulated, were placed on the temples (near both eyes), neck (on and under the lead protector) and on both hands, as can be seen in Figure 1A, 1B and 1C, respectively.

It must be said that the staffs were not fixed, that is, from one examination to another, professionals took turns in the room. For this reason, the doses obtained are an estimative, if always the same staff remained inside the examination room.

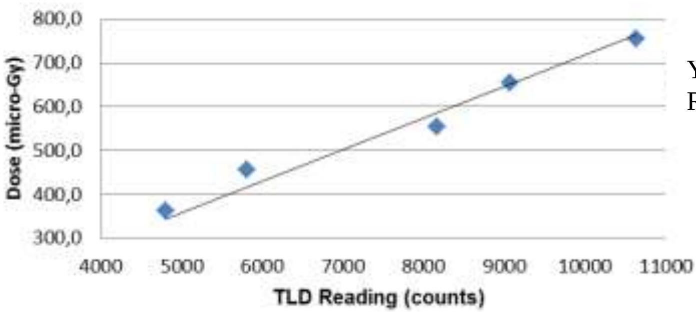
After all 37 procedures, the measured equivalent doses were summarized for each assistant to obtain the accumulated equivalent doses ($H_{t\ Ac}$), for each region. Then $H_{t\ Ac}$ was divided by 37, in order to calculate the mean value of equivalent dose for one procedure ($H_{t\ Proc}$). And finally, $H_{t\ Proc}$ was multiplied by 720 (estimated number of pediatric barium meal procedures per year performed at the hospital) to obtain the estimated annual equivalent dose ($H_{t\ an}$).

Figure 1. A) The MCP TLDs (envelop 1) are positioned near the assistant's left eye; B) The MCP TLDs (envelop 2) are positioned on the assistant's neck (under the lead protector); C) The MCP TLDs (envelops 3 and 4) are positioned on the assistant's hands.

3. RESULTS AND DISCUSSION

The Figure 2 shows the linear graph Dose x TLD reading, and its equation – which has a coefficient (0.0718) that must be multiplied for the future TLD reading, so that the absorbed dose by the dosimeter is determined. The equation error is 0.0005.

Table 1 shows estimated values of $H_{t\ Ac}$, $H_{t\ Proc}$ and $H_{t\ An}$, for each area and for both staffs and the ICRP 103 and NCRP guidelines.



Y = 0.0718 X
R^2 = 0.9687

Figure 12. Dose ("Y") x TLD reading ("X") graph showing the linear equation. The coefficient 0.0718 must be multiplied for the future TLD reading, so that the dose can be verified.

Table 1. Estimative of the equivalent doses (mSv) received by the assistants, in each region, and the comparison with the ICRP and NRCP recommendations [6,7].

	Eyes			**Thyroid (under the lead protector)**			**Hands**		
	$H_{t\ Ac}$	**$H_{t\ Proc}$**	**$H_{t\ An}$**	**$H_{t\ Ac}$**	**$H_{t\ Proc}$**	**$H_{t\ An}$**	**$H_{t\ Ac}$**	**$H_{t\ Proc}$**	**$H_{t\ An}$**
Staff 1	1.8	0.05	36	1.1	0.03	22	3.1	0.08	58
Staff 2	0.6	0.02	14	0.5	0.01	7	0.7	0.02	14
ICRP 103	----	----	20	----	----	----	----	----	500
NCRP						150			

It is observed that the eyes annual equivalent dose of the assistant 1 was found to be 80% higher than the annual limit set by the ICRP 103, and the assistant 2 received 70% of the limit. The other equivalent doses are much lower than the ICRP and NCRP recommendations.

However, the same does not happen when the doses are compared to the mentioned studies (Table 2).

It is verified that the results obtained for the current study are much higher (for both assistants) than the researchers used for comparison, even the one performed in brain angiography (an interventional procedure). Nevertheless, it should be reiterated that the obtained doses were not received by fixed staffs; but all the different professionals remained in the same positions.

Although, if fixed staffs stayed inside the examination room, optimization techniques should be implemented so that lower doses can be achieved.

Table 2. Estimative of the equivalent doses in each procedure (μSv/procedure) – $H_{t\ Proc}$ – received by the assistants, in each region, and the comparison with other studies.

	Staff 1		
	Eyes	**Thyroid (on the lead protector)**	**Hands**
Current Study	49.2 ± 1.5	52.0 ± 2.0	83.6 ± 7.5
Coakley [4]	------	1.5 ± 0.4	5.8 ± 1.0
Lunelli [5]	1.7 ± 0.3	1.2 ± 0.2	1.9 ± 0.3
	Staff 2		
	Eyes	**Thyroid (on the lead protector)**	**Hands**
Current Study	16.5 ± 0.9	19.6 ± 1.5	22.4 ± 0.9
Coakley [4]	------	1.5 ± 0.4	5.8 ± 1.0
Lunelli [5]	1.7 ± 0.3	1.2 ± 0.2	1.9 ± 0.3

4. CONCLUSIONS

The aim of the current study was to estimate the occupational equivalent doses for eyes, thyroid and hands for both staffs that perform BM procedures in children. It was verified that the eyes annual equivalent dose of the assistant 1 was found to be 80% higher than the annual limit set by the ICRP 103, and the assistant 2 received 70% of the limit. The other equivalent doses were much lower than the recommendations. However, the results obtained for the current study were much higher (for both assistants) than the researchers used for comparison. Nevertheless, if fixed staffs stayed inside the examination room, optimization techniques should be implemented so that lower doses can be achieved.

5. REFERENCES

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