IL NUOVO CIMENTO **41 C** (2018) 213
DOI 10.1393/ncc/i2018-18213-6

Colloquia: SIRR 2018

# Evaluation of the dose dependence on the eye lens from the position of the dosimeter for the operators exposed in interventional radiology

A. Liverani(1), F. Loffredo(1)(2), F. Fiore(3), M. Correra(3), G. La Verde(1)(2) and M. Pugliese(1)(2)(*)

(1) *Dipartimento di Fisica "Ettore Pancini", Università degli Studi di Napoli "Federico II" Napoli, Italy*
(2) *Istituto Nazionale di Fisica Nucleare, Sezione di Napoli - Napoli, Italy*
(3) *Istituto Nazionale Tumori, IRCCS Fondazione "G. Pascale" - Napoli, Italy*

received 4 December 2018

**Summary.** — The 2013/59 EURATOM Directive of the 5th of December lays down basic safety standards concerning protection against dangers arising from exposure to ionizing radiation. The Directive lowers the limit on equivalent doses to the eye lens from 150 mSv to 20 mSv per year, according to the publication 103 of ICRP. The aim of this work is to evaluate the current status of the eye lens radiation exposure in an Interventional Radiology Department depending on the position of the specific dosimeters used by exposed workers, to compare the measured doses with the limit imposed by the Directive. Methods: the equivalent dose was assessed, over a period of 30 days, using four specific Hp dosimeters (Ainsbury E. A. *et al.*, *Mutat. Res./Rev. Mutat. Res.*, **770,** Part B (2016) 238), placed in four different points on a personal protective device. For each dosimeter we evaluated the equivalent dose absorbed and we compared these doses with the new limits of the 2013/59 EURATOM Directive.

## 1. – Introduction

Nowadays, the use of ionizing radiations is increasing in the health context, both for diagnostic activities and for therapy activities. However, ionizing radiation is harmful to the body, therefore it was necessary to recommend a radiological protection system, both for patients and for doctors and for all the staff exposed to radiation. Focusing our attention on exposed medical workers, the limit on the equivalent dose to the lens for

(*) Corresponding author. E-mail: pugliese@na.infn.it

 

TABLE I. – *Performance of a TLD dosimeter for eye lens.*

| | |
|---|---|
| Detectors | Hp(3) LiF(Mg, Cu, P), GR-200A |
| Filtration: | 1 mm ABS (about 20 mg/cm$^2$) for the determination of Hp(3) values |
| Response interval in energy ($n$): | Photons: 20 keV–3 MeV |
| Dependence of the response in terms of Hp(3) in the measured energy range: | $< \pm 25\%$ |
| Dependence of the response in terms of Hp(3) as a function of the angle of incidence (max 60°): | $< \pm 15\%$ |
| Minimal detectable dose (with 95% confidence in routine procedures): | Not more than 20 $\mu$Sv |
| Minimum certifiable dose (with 95% confidence in routine procedures): | Not more than 50 $\mu$Sv |

these professional figures was re-defined, lowering it from 150 mSv per year to 20 mSv per year. As the eye lens is one of the most radiosensitive organs in the human body, its exposure to radiation may affect its integrity leading to the formation of lens opacities [1]. Recent studies have shown that radiation-induced cataracts are not exclusively the result of high doses over a short period of time [2-9]. Nurses, technicians and, in particular, operators working closely with the patient (which is the main source of diffuse radiation) are health personnel with high levels of occupational exposure to ionizing radiation. In the hospital in which we performed dose measurements, the eye lens equivalent dose is extrapolated from the effective dose, obtained with the use of a dosimeter for whole body Hp(10), with the Martin formula. The correlation between the eye lens dose and the Hp(10) measured over the apron has been investigated in various studies [10,11]. This correlation is affected by several variables like the beam quality, the angular response of the dosimeter, the operator position, the use of glasses and the position of non-structural shielding. All these variables provide a high dispersion in the relationship between these two magnitudes, but on average, the Hp(10) or Hp(0.07) tend to overestimate the dose for the eye lenses which can be interpreted as a conservative estimate [12].

## 2. – Materials and methods

The measurement of the eye lens equivalent dose was obtained by reading the Hp(3) dosimeters worn by operators. Table I shows the technical characteristics of the dosimeters.

These devices were worn for a period of 30 days so they are preliminary results. The dosimeters were placed in four different position: 1) laterally to the left on the outside of the glass (fig. 1(a)); 2) laterally to the right on the outside of the glass (fig. 1(b)); 3) frontally outside (fig. 1(c)); 4) laterally to the left on the inside of the glass (fig. 1(d)).

The device used in radiology to monitor the patient in angiography is the image intensifier. The image intensifier is enclosed in a vacuum glass container. The X-ray

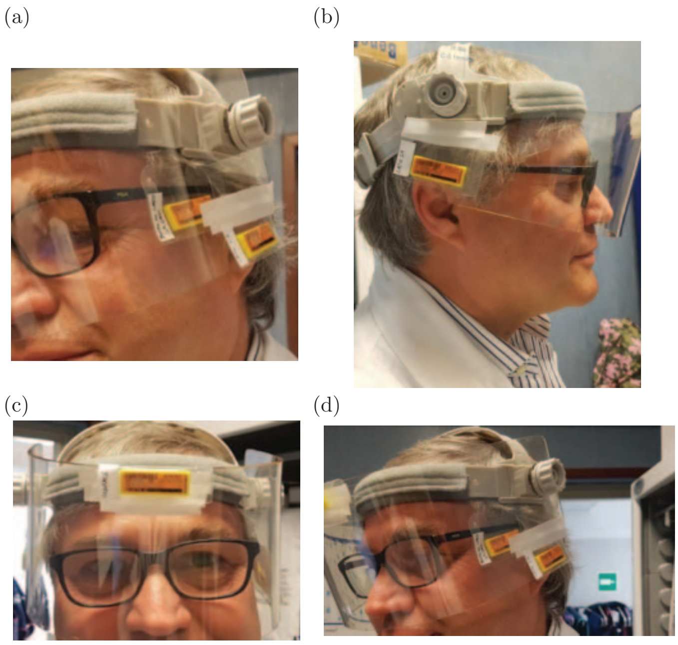

Fig. 1. – Four different positions were considered for the placement of the dosimeters (see text for their description).

Table II. – *Value of the equivalent dose according to the dosimeter position.*

| Dosimeter | Dose (mSv) |
|---|---|
| 1) Laterally to the left on the outside of the glass | 0.127 |
| 2) Laterally to the right on the outside of the glass | 0 |
| 3) Frontally outside | 0.057 |
| 4) Laterally to the left on the inside of the glass | 0 |

image is transformed into a luminous image by a fluorescent layer and then converted into an electronic image by photocathode. The electrons are thus accelerated by means of a potential difference between the cathode and the anode, collimated by electrostatic grids, then projected onto a fluorescent screen at the base where a very bright image forms. The image can then be taken directly or via coupling optics via a CCD camera.

## 3. – Results

For the operator there were acquired, regarding the type of examination, the duration of the exam and some machine parameters (as shown in table II). From these data an exposure time of 19 minutes for each dosimeter, over the 30 days period was extrapolated.

Dosimeter readings provided an equivalent dose in terms of Hp(3) are reported in table II.

Results highlighted a difference between exposure doses. In particular the first dosimeter (laterally on the left outside glass) provides the highest dose.

In 2017, the machine was used for 4330 minutes while over the 30 days it was used for 19 minutes. Through the ratio between these worktimes of the machine, the number of interventions could be approximated to 233 from the 19 minutes it performed in a year. From the results we can estimate the dose in one year as being:

1) $0.127\,\text{mSv} \cdot 233 = 29.6\,\text{mSv/year}$;

2) $0\,\text{mSv} \cdot 233 = 0\,\text{mSv/year}$;

3) $0.057\,\text{mSv} \cdot 233 = 13.3\,\text{mSv/year}$;

4) $0\,\text{mSv} \cdot 233 = 0\,\text{mSv/year}$.

Results showed that the first dose exceeds the limit of 20 mSv/year imposed by the Directive.

To evaluate the differences between the exposure levels detected by the different dosimeters (Hp(3) and Hp(10)), the Institute of health Physics Service has provided whole body dose values of the operator obtained from Hp dosimeters (10), placed above the leaded aprons. This value is 0.48 mSv/year.

Using the Martin formula, we can obtain the dose for the eye lens by multiplying the value of the whole body worth dosimeter by 0.75 and it is therefore a dose equal to 0.36 Sv/year. Therefore, in this way there is an underestimation of the equivalent dose of eye lens obtained with Hp(3).

If glasses were used with the highest anti-X protection factor (0.7), the exposure dose would be greatly reduced (eq. (1)),

$$29.6 \cdot (1 - 0.7) = 8,88\,\text{mSv/year}. \tag{1}$$

As shown by this result, using lenses with the maximum protection factor the measured dose would fall within the limit imposed by the 2013/59 Directive of 20 mSv.

## 4. – Discussion and conclusion

In conclusion, we observed that the measured equivalent dose depends on the position taken by the dosimeter with respect to the glasses. The dosimeter placed on the left side of the glasses provided a dose that exceeds the limit imposed by the Directive 2013/59. If glasses with the highest X-ray attenuation factor will be used, the measured dose would be significantly reduced. So, the use of personal protective equipment is very important in an interventional radiology.

REFERENCES

[1] Miller D. L., Vano E., Bartal G. *et al.*, *Cardiovasc. Intervent. Radiol.*, **33** Suppl. 2 (2010) 230.
[2] Ainsbury E. A., Barnard S., Bright S., Dalke C., Jarrin M., Kunze S., Tanner R., Dynlacht J. R., Quinlan R. A., Graw J., Kadhim M. and Hamada N., *Mutat. Res./Rev. Mutat. Res.*, **770,** Part B (2016) 238.
[3] Ainsbury E. A., Bouffler S. D., Dorr W. *et al.*, *Radiat. Res.*, **172** (2009) 1.
[4] Chodick G., Bekiroglu N., Hauptmann M. *et al.*, *Am. J. Epidemiol.*, **168** (2008) 620.

[5] Jacob S., Michel M., Spaulding C. *et al.*, *BMC Public Health*, **10** (2010) 537.
[6] Rose A., Rae W. I. D., Chikobvu P. and Marais W., *J. Radiol. Prot.*, **37** (2017) 329.
[7] Shore R. E., *Mutat. Res./Rev. Mutat. Rev.*, **770,** Part B (2016) 231.
[8] Thome C., Chambers D. B., Hooker A. M., Thompson J. W. and Boreham D. R., *Health Phys.*, **114** (2018) 328.
[9] Vano E., Kleiman N. J., Duran A. *et al.*, *J. Vasc. Interv. Radiol.*, **24** (2013) 197.
[10] Miller D. L., Vano E., Bartal G. *et al.*, *Cardiovasc. Intervent. Radiol.*, **33**, Suppl. 2 (2010) 230.
[11] Principi S., Ginjaume M., Duch M. A. *et al.*, *Radiat. Prot. Dosim.*, **164** (2015) 79.
[12] Martin C. J., *Radiat. Prot. Dosim.*, **136** (2009) 140.