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ARTICLE

Use of personal radiation protection tools and individual dosimetric monitoring in a sample of interventional cardiologists in France, 2005–2009

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Abstract – Interventional cardiologists (ICs) are repeatedly exposed to scattered ionising radiation during the cardiac procedures they perform, and radiation protection is an important issue for these medical professionals. The use of radiation protection tools is particularly relevant to this population. SISERI (Système d'Information de la Surveillance de l'Exposition aux Rayonnement Ionisants, that is, an information system for monitoring exposure to ionising radiation) is a register that stores personal dosimeter readings for dosimetric monitoring. This paper, based on data for a sample of French ICs from the O'CLOC epidemiological study, aims to provide an overview of the use of radiation protection equipment and dosimetric devices reported by ICs in a specific questionnaire as well as the dosimetric information found in the SISERI database for this population. *Material and Methods* – Annual information on interventional cardiology activity for the period from 01/01/2005 to 31/12/2009 was collected in an occupational questionnaire. ICs were asked to report the frequency in which they used individual dosimeter and radiation protection tools (lead apron, thyroid shield, eyewear or face shield, ceiling-suspended shield) as follows: never (0% of the time), occasionally (<50%), regularly (>50%), always (100%). We retrieved their medical radiation exposure information (monitored status and monthly effective doses) from the SISERI database for the period 2005–2009. *Results* – Information for 132 ICs (mean age in 2005 = 46 ± 7 years) was available. All ICs reported routine use of lead aprons, in contrast to their occasional use of lead eyewear or face shields. During the study period, 49% reported systematic use of personal dosimeters, and 21% more regular use. On the other hand, 18% never used a dosimeter during this period. The SISTERI database included 92% of our population, 73% of whom had complete annual dose monitoring in SISERI (corresponding to at least 11 months per year of recorded data). *Conclusion* – ICs must improve their regular use of radiation protection tools and systematic use of personal dosimeters. The SISERI database is an appropriate tool for flagging those medical professionals exposed to ionising radiation. Better awareness of the importance of radiation protection rules in this population, in particular, systematic dosimeter use, remains an important issue.

Keywords: medical radiation / occupational exposure / radiation protection / radiation monitor

1 Introduction

Because interventional cardiologists (ICs) are repeatedly exposed to scattered ionising radiation during the cardiac procedures they perform, radiation protection is an important issue for these medical professionals. The annual effective dose limit for ICs, as for all radiation workers, is 20 mSv per year. Moreover, it has previously been observed that these physicians' eyes are particularly exposed (Jacob *et al.*, 2013), and they may develop radiation-induced cataracts when radiation protection measures are not used (Ciraj-Bjelac *et al.*, 2010; Vano *et al.*, 2010; Jacob *et al.*, 2012). In April 2011, on the basis of epidemiological and biological studies, the International Commission on Radiological Protection (ICRP) revised its lifetime eye dose threshold for cataract induction downwards from 2 Gy to 0.5 Gy, and the annual occupational eye dose limit from 150 mSv to 20 mSv per year (ICRP, 2009, 2011). The lack of an appropriate eye dosimeter makes it difficult to verify whether this substantial dose reduction is met, especially in view of the incomplete use of radiation protection tools to limit the exposure of the eyes and of the whole body to ionising radiation (Lie *et al.*, 2008; Gualdrini *et al.*, 2011; Sanchez *et al.*, 2012; Farah *et al.*, 2013). In such a context, wearing whole-body dosimeters is essential for monitoring the cumulative dose received by ICs. A previous study in Latin America (Vano *et al.*, 2010) reported that many of the ICs participating in their survey stated that they did not use their personal dosimeters regularly, but furnished no details. A similar

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situation was observed in Spain (Sanchez *et al.*, 2012). Before we began the O'CLOC epidemiological study (Occupational Cataracts and Lens Opacities in Interventional Cardiology) (Jacob *et al.*, 2010), little was known about radiation protection among ICs in France. In this paper, we use a sample of French ICs from that study (Jacob *et al.*, 2010) to describe self-reported use of individual dosimeter and radiation protection tools by these specialists, but also information of dosimetric monitoring registered in the SISERI (Système d'Information de la Surveillance de l'Exposition aux Rayonnement Ionisants, that is, an information system for monitoring exposure to ionising radiation) database, to obtain an overview of radiation protection as it was actually practised by ICs from 01/01/2005 to 31/12/2009.

2 Material and methods

2.1 Questionnaire

The aim of the O'CLOC study was to analyse the risk of radiation-induced cataracts among ICs (Jacob *et al.*, 2010). As part of this study, we developed a specific questionnaire to collect information about lifetime occupational activity, intended to obtain as complete and precise a picture as possible of the workload of ICs as well as their use of radiation protection equipment, including lead aprons, in particular, but also lead thyroid shields, lead eyewear and face shields, and ceiling-suspended shields in every centre where they had worked or were working. Moreover, for each year of activity, ICs were asked to report their frequency of use of individual dosimeters and each listed radiation protection tool as follows: never (0% of the time), occasionally (<50%), regularly (>50%), always (systematically) (100%).

2.2 Individual monitoring

Dosimetric monitoring of workers exposed to ionising radiation is based on individual monitoring of exposure through personal dosimeters. In France, all individual monitoring data for all exposed workers are centralised in the national SISERI database[1], which is managed by the IRSN. Since 2005, the information centralised in SISERI has been collected directly from dosimetry laboratories by automatic transfer, via a dedicated website, immediately after development of the measurements, in contrast to previous years when information was collected retrospectively from the SCPRI (Service central de protection contre les rayonnements ionisants) and OPRI (Office de protection contre les rayonnements ionisants). Every year, SISERI receives individual dosimetric data for all workers monitored in France (more than 350 000 in 2012, including more than 220 000 medical personnel).

Several steps govern the measurement process, from use of the dosimeter to the final recording of a dose in SISERI. The dosimeter measures an individual's cumulative exposure to IR. Accurate measurement first requires that dosimeters be worn correctly: only appropriate use of the dosimeter can produce a relevant exposure measurement. Secondly, dosimeters are sent to specialised laboratories approved by the French nuclear authority for development, that is, to determine the doses measured by dosimeters. These laboratories then transfer their measurements directly to SISERI for recording. French regulations require that personal dosimeters be worn at chest level, under the lead apron, and that doses be recorded monthly or quarterly. Moreover, a dose recorded in the SISERI database as 0 mSv means that dose was below the detection limit of the dosimeter. All dosimetric data of the cardiologists who responded to the O'CLOC questionnaire were extracted from the SISERI database.

2.3 Study period and data analysis

This study is intended to describe the use of radiation protection tools and personal dosimeters and doses registered in SISERI for our sample of interviewed ICs from 01/01/2005 to 31/12/2009 (endpoint of the O'CLOC study).

Based on annual information collected from the questionnaire, we present for the study period the mean self-reported frequency of use of an individual dosimeter (never (0% of the time), occasionally (<50%), regularly (>50%), always (100%) and of different radiation protection tools. Based on the information and doses recorded each year in SISERI, we also present for the same period the mean number of months each year for which SISERI contains information, as follows: complete year (for at least 11 months with recorded information), incomplete year (for less than 11 months with registered information), no data (for 12 months with missing information). Moreover, for a subsample of cardiologists with complete years of monitoring in SISERI, we describe the mean doses recorded.

3 Results

The O'CLOC study analysed the data over the study period for 132 ICs, whose mean age at the beginning of that period (2005) was 46 ± 7 yrs.

During this period, all ICs reported that they always used lead aprons, more than 80% always used thyroid shields and 60% always used ceiling-suspended shields. More than half the ICs never used eye protection, while 34% always did (Tab. 1). Overall, 70% of cardiologists reported they wore a personal dosimeter regularly (>50% of the time), but only 49% always; at the same time, 18% reported that they never wore their dosimeters (Tab. 1).

More than 70% of ICs had complete monitoring years in SISERI (*i.e.*, at least 11 months of recorded monitoring), but around 10% had no dosimetric information registered in the database. Indeed, 11 ICs (8%) had no monitoring at all during these 5 years: 7 of them worked at the same centre, which had no dosimeters available, while 3 others reported that they never used their dosimeter, and one used it occasionally. The analysis of the distribution of frequency of dosimeter use according to the completeness of annual data in SISERI (see Fig. 1) shows that among ICs with at least one complete monitoring year in the database, more than half reported that they always used their dosimeter. This percentage reached 75% for systematic and regular use. However, discrepancies between the

[1] http://siseri.irsn.fr/

Table 1. Description of declared frequency of use of radiation protection tools, individual dosimeters and dose monitoring for the period 2005–2009.

	% of cardiologists (n = 132)
Use of lead apron[a]	
Always (100%)	100%
Use of lead thyroid shield[a]	
Never (0%)	10%
Occasionally (<50%)	6%
Regularly (>50%)	1%
Always (100%)	83%
Use of lead eyewear[a]	
Never (0%)	53%
Occasionally (<50%)	11%
Regularly (>50%)	2%
Always (100%)	34%
Use of lead face shield[a]	
Never (0%)	95%
Occasionally (<50%)	2%
Regularly (>50%)	0%
Always (100%)	3%
Use of ceiling-suspended shield[a]	
Never (0%)	27%
Occasionally (<50%)	11%
Regularly (>50%)	2%
Always (100%)	60%
Use of personal dosimeter[a]	
Never (0%)	18%
Occasionally (<50%)	12%
Regularly (>50%)	21%
Always (100%)	49%
Monthly dose records[b]	
Complete year ($\geqslant$11 months)	73%
Incomplete year (1 to 10 months)	16%
No data (No month)	11%

[a]From the O'CLOC questionnaire.
[b]From the SISERI database.

questionnaire and the information from SISERI were observed for 10% of ICs, who reported never using their dosimeter, although SISERI contained at least a complete year of follow-up for them.

Among ICs with incomplete years in SISERI, *i.e.*, fewer than 11 months in a year, about half reported always using their dosimeter; this figure reached 75% when regular users were included, and 15% of them reported never using it. More than 60% of ICs with no data recorded in SISERI reported they never used a dosimeter. One, however, reported always using it, although SISERI contained no data for him.

When we looked only at ICs with complete follow-up in the database (n = 96), we observed that more than 61% of the recorded monthly doses were below the dosimeter's detection limit (see Tab. 2). The median annual cumulative dose was 0.9 mSv. Overall, nearly 50% of the cardiologists received non-significant doses (below the detection limit and thus far below 20 mSv/year) and only one IC had a recorded dose above 20 mSv in 2005. The results remained in this range throughout the study period.

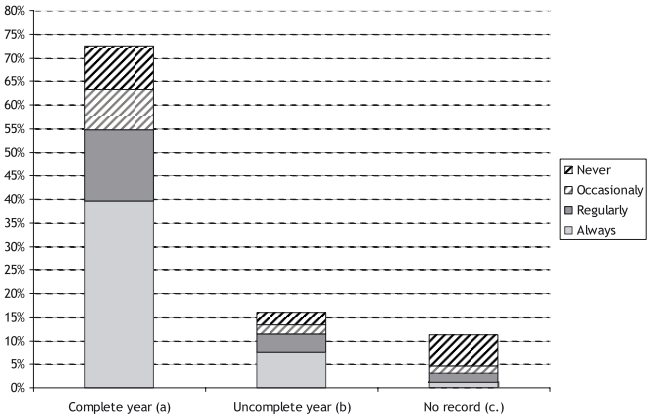

Fig. 1. Mean annual distribution of self-reported use of personal dosimeters according to the number of months with dose records; (a) at least 11 months recorded in the SISERI database; (b) 1 to 10 months recorded in SISERI; (c) 0 months recorded in SISERI.

Table 2. Description of effective doses recorded for cardiologists with complete years of monitoring for the period 2005–2009.

	% of cardiologists (n = 96)
Months with doses below the dose detection limit (dose = 0 mSv)	
$\geqslant$11 months	61%
6 to 10 months	27%
1 to 5 months	11%
0 months	1%
Cumulative annual dose (mSv)	
Median	0.00
(Interquartile range)	(0.00 – 0.44)
Cardiologists with annual dose =0 mSv	46%
Cardiologists with annual dose >20 mSv	1%
Highest annual dose (mSv)	21.64 (1 cardiologist in 2005)

4 Discussion

In a sample of 132 French ICs, we observed that all reported that they always wore their lead apron throughout the study period. The eyes were the least protected area: only around half the ICs reported regular use of radiation protection eyewear or face shields. Although more than half reported always using a dosimeter, a rather high percentage of ICs (30%) reported that they had either never or only occasionally used it. We thus observed inadequate personal dosimeter use by some ICs.

More than 90% of the ICs in our sample were found in the SISERI database. The other 10% worked at one centre that did not use personal dosimeters at all. This finding demonstrates that this national dose register is a very good tool for finding potentially exposed French ICs and, more generally, medical workers. It should nonetheless be mentioned that the quality of the dosimetric monitoring data recorded in the SISERI database depends on ICs (and all other IR-exposed workers) using personal dosimeters correctly and turning them in for development and data transfer. Note that 18% of ICs reported that they never used a dosimeter.

This study also showed that self-reported dosimeter use conflicted in some cases with data recorded in SISERI: some

ICs who reported regular dosimeter use were not included in SISERI (around 30%), when some others, who reported they never used a dosimeter, had at least some months with dosimetric records (around 10%). These figures mainly illustrate the general limitations of questionnaires. However, they also suggest the possible undervaluation of the effective doses to ICs, when only information recorded in SISERI is recorded. Nevertheless, a complete annual follow-up in SISERI was available for most ICs. This is the first study presenting such detailed results; they are concordant with what was expected but not quantified in previous studies (Vano *et al.*, 2006; Sanchez *et al.*, 2012).

Because chest dosimeters are worn under the lead apron in France, doses cannot be correlated with those received at eye level for assessing the eye dose or cataract risk. In Finland, however, a study of radiation-induced cataracts considered measurements from chest dosimeters worn outside the lead apron as indicators of the eye dose (Mrena *et al.*, 2011). The validity of this study depends on two assumptions: that individual dosimeters were always worn and that chest dosimeters are a good indicator of eye exposure. While the first point may be possible, the second assumption may be less accurate, as detailed in a recent paper (Farah *et al.*, 2013).

Analysis of annual doses in the SISERI database showed that the median effective dose for ICs was always far below 20 mSv/year, except for one IC in 2005. These results on doses appear concordant with those observed in a small sample of 28 Spanish ICs (Sanchez *et al.*, 2012) and comply with the threshold limit of <20 mSv/year (ICRP, 2007). Although the lack of regular dosimeter use might cause these doses to be underestimated, the observed doses in this study remained so far from 20 mSv that it is improbable that this threshold is being exceeded.

Data for the period 2010–2013 should provide information about the progress in IC awareness of radiation protection. This type of information will be obtained through a new questionnaire, as the collection of epidemiological data in the O'CLOC study ended in December 2009.

5 Conclusion

This study showed that use of radiation protection tools and personal dosimeters and, more generally, awareness of radiation protection rules is far from universal for interventional cardiologists and requires improvement. We found that the SISERI database is an appropriate tool for flagging exposed interventional cardiologists and other medical workers. However, the representativeness of the passive doses registered in the SISERI database depends on the systematic and correct use of personal dosimeters, which is not always the case. Improving dosimetric monitoring and radiation protection of medical workers remains a key point that could be enhanced with more detailed data in the SISERI database than passive dosimetry. Use of active dosimetry and extremity dosimetry should be encouraged.

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