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RADIATION DOSES TO PATIENTS IN INTERVENTIONAL CORONARY PROCEDURES—ESTIMATION OF UPDATED NATIONAL REFERENCE LEVELS BY DOSE AUDIT

Jean-Louis Georges[1,2,*], Loic Belle[2,3], Cécile Etard[4], Jean-Baptiste Azowa[1], Franck Albert[2,5], Michel Pansieri[2,6], Jacques Monsegu[2,7], Franck Barbou[2,8], Charlotte Trouillet[2,9], Pierre Leddet[2,10], Bernard Livarek[1,2], Xavier Marcaggi[2,11], Michel Hanssen[2,10], Simon Cattan[2,12] and the RAY'ACT-2 investigators[2,13]

[1]Service de Cardiologie, Centre Hospitalier de Versailles, 78150 Le Chesnay, France
[2]Collège National des Cardiologues des Hôpitaux, Paris, France
[3]Service de Cardiologie, Centre Hospitalier d'Annecy-Genevois, Annecy, France
[4]Institut de Radioprotection et de Sureté Nucléaire, PRP-HOM/SER, BP17, 92262 Fontenay-aux-Roses, France
[5]Service de Cardiologie, Hôpital Louis Pasteur, Chartres, France
[6]Service de Cardiologie, Centre Hospitalier d'Avignon, Avignon, France
[7]Service de Cardiologie, Groupe Hospitalier Mutualiste, Grenoble, France
[8]Service de Cardiologie, Hôpital d'instruction des Armées du Val de Grâce, Paris, France
[9]Service de Cardiologie, Groupe Hospitalier de la Rochelle-Ré-Aunis, La Rochelle, France
[10]Service de Cardiologie, Centre Hospitalier de Haguenau, Haguenau, France
[11]Service de Cardiologie, Centre Hospitalier Jacques Lacarin, Vichy, France
[12]Service de Cardiologie, Groupe Hospitalier Intercommunal Le Raincy-Montfermeil, Montfermeil, France
[13]RAY'ACT-2 investigators See Appendix.

*Corresponding author: jgeorges@ch-versailles.fr

The objective of this study was to estimate the French national updated reference levels (RLs) for coronary angiography (CA) and percutaneous coronary intervention (PCI) by a dose audit from a large data set of unselected procedures and in standard-sized patients. Kerma-area product (P_{KA}), air kerma at interventional point (Ka,r), fluoroscopy time (FT), and the number of registered frames (NFs) and runs (NRs) were collected from 51 229 CAs and 42 222 PCIs performed over a 12-month period at 61 French hospitals. RLs estimated by the 75th percentile in CAs and PCIs performed in unselected patients were 36 and 78 Gy.cm² for P_{KA}, 498 and 1285 mGy for Ka,r, 6 and 15 min for FT, and 566 and 960 for NF, respectively. These values were consistent with the RLs calculated in standard-sized patients. The large difference in dose between sexes leads us to propose specific RLs in males and females. The results suggest a trend for a time-course reduction in RLs for interventional coronary procedures.

INTRODUCTION

Interventional cardiology (IC) procedures are important contributors of exposure to ionising radiation in the general population in Europe(1) and in the USA(2). Exposure of patients to X-rays during IC procedures is high and may have deleterious effects(3, 4). Guidelines and position papers have emphasised the need for interventional cardiologists to improve their knowledge of patient exposure levels and their awareness of the risks of radiation by continuous training in radiation protection and the development of quality-assurance programmes(3–6). Diagnostic reference levels (DRLs) are a quality-assurance and improvement tool for controlling radiation dose(6–9). DRLs are already used for non-invasive diagnostic cardiac imaging(10). Reference levels (RLs) have also been proposed for dose management for fluoroscopically guided interventional procedures, including IC, although there are some methodological issues(8, 9, 11). Moreover, there are different methods for specifying RLs(9). The 75th percentile (third quartile) is commonly used, and frequently the 75th percentile of the distribution of the dose parameter in the total study population. The proposal of the International Commission on Radiation Protection (ICRP) is to, in future, preferentially use the 75th percentile of the medians measured in the facilities that participate in multicentre surveys(12). Preliminary national and international RLs have been proposed for diagnostic coronary angiography (CA) and percutaneous coronary intervention (PCI) in different settings and using various methods(9, 11, 13–24).

The RAY'ACT project is a French nationwide multicentre survey aimed at evaluating and improving current practices for patient radiation protection in IC. It is mainly based on a benchmark provided by a dose-audit process, as previously described(9, 11, 17).

The first transversal RAY'ACT study established RLs in 2010–2011 and suggested a continuous trend for a reduction in RLs for CA and PCI[24]. The present publication presents the results of the second RAY'ACT study, conducted in 2014, whose objectives were to update national RLs for IC procedures, to compare RLs estimated from a dose audit in a large data set of unselected procedures to RLs estimated in standard-sized patients, and to confirm the trend for a time-course decrease in patient exposure.

METHODS

The RAY'ACT survey

Patient's Exposure to X-Ray During CA and Percutaneous Transluminal Coronary Intervention (RAY'ACT) is a French nationwide project that includes a series of transversal, investigator-driven, industry-independent, observational retrospective and prospective studies. The project is conducted by the 'College National des Cardiologues', a professional college of the French Society of Cardiology. The main objectives were to evaluate current practices of patient radiological protection for IC procedures, to provide to IC centres and cardiologists data on patient exposure for their practice and a benchmark, and finally to contribute to reducing unnecessary patient exposure. Surveys of non-selected exams performed in the previous year are repeated periodically to characterise trends in clinical practice and imaging technologies as they relate to radiation dose. For the second RAY'ACT study, 81 IC centres from public hospitals, non-profit private hospitals and military hospitals were invited to participate, provided they complied with a minimal set of conditions: routine registration of examination data including radiation protection parameters (at least kerma-area product, P_{KA}) by means of local software, and ability to perform on-site CAs and PCIs 24 hours a day, 7 d a week. Of the 81 centres, 66 agreed to participate in the study; five centres could not send relevant data and were excluded. This analysis is, therefore, based on data provided by 61 centres (227 senior interventional cardiologists), 44 of which participated in the RAYACT-1 study and 17 were new centres.

Data collection

Methods for data collection were the same as reported in the first RAY'ACT study[24]. Briefly, data from CAs and PCIs performed from 1 January to 31 December 2013 were collected from the 61 centres using local software. For each procedure, the following data were collected: patient characteristics (age, sex, body mass index [BMI], clinical indication for procedure), procedural details, and dosimetry indicators. Patient identities were preserved according to current ethical regulations, and the study was approved by national ethics committees (Comité Consultatif sur le Traitement de l'Information en matière de Recherche dans le domaine de la Santé, and Commission Nationale de l'Informatique et des Libertés).

Dose metrics

In this study, we collected data on P_{KA} expressed in Gy.cm² (also known as dose area product [DAP]), total air kerma at interventional reference point (Ka,r) expressed in mGy (also known as reference dose or cumulative dose), fluoroscopy time (FT) in min, number of acquisition runs (NRs) and number of frames (NFs), when available.

Equipment

The radiological equipment comprised of 77 cardiovascular X-ray imaging systems (two systems in 16 centres, and one in 45) from four different manufacturers and installed between 1998 and 2013 (87% of which had a flat panel detector). In accordance with the national quality-control protocol, established in 2005, all X-ray equipment in France should be checked each year to ensure it complies with technical requirements and tolerances that relate to patient dosimetry and image quality. These include, amongst others, assessment of high-contrast spatial resolution under different magnification modes, maximum permissible entrance patient dose, and precision of installed P_{KA}-measuring devices and accuracy of X-ray generator parameters (kV and mA, reproducibility). As a consequence, no specific or complementary quality-control checks of equipment were required before starting the study.

Statistical analysis

Radiation dose parameters were analysed separately for diagnostic CA, PCI without CA and combined procedures (CA immediately followed by a PCI in the same procedure). For the purpose of comparison with previous RLs, results were also provided for all PCI (PCI alone and PCI performed in combined procedure). Continuous data are presented as medians and interquartile ranges (IQRs), and correlations were tested by linear (r) and nonparametric Spearman's rank (rho) correlation coefficient tests as appropriate. In the present study, RLs were defined as the rounded value of the third quartile (75th percentile) of the overall distribution for each parameter, as previously described[7, 9, 17, 24]. Estimates of RLs obtained by this method are also named the 'advisory data set' (ADS)[9]. As patient weight and BMI impact on both P_{KA} and Ka,r, the European methodology recommends that only standard-sized patients be included. Therefore, RLs were also calculated in subgroups of standard-sized male and female patients whose weight and BMI were between the 40th and 60th percentile of the distributions in each sex. Finally, in order to comply with the new ICRP recommendations[12], we also calculated DRLs defined as the 75th percentile of the medians in the 61 centres. All statistical analyses were carried out with IBM SPSS Statistics version 23.0 (SPSS Inc., Chicago, IL).

RESULTS

Data were obtained for 51 229 CAs and 42 222 PCIs. The number of procedures by centre ranged from 426 to 1842 for CA (median 754, quartiles 579–1076), and from 287 to 1739 for PCI (median 659, quartiles 498–822). Patient and procedure baseline characteristics are shown in Table 1. Medians (40th–60th percentiles) of weight and BMI were 80 (78–85) kg and 26.9 (26.0–28.1) in males, and 68 (64–70) kg and 26.4 (25.0–27.7) in females, respectively. Most of the PCI were performed immediately after diagnostic CA in the same procedure, and the radial route was used in >80% of procedures.

Table 2 and Figure 1 show the distributions of dose parameters for CA and PCI. There was no significant correlation between the volume of procedures and the median P_{KA} of the centres (r = 0.14 for CA, and r = 0.05 for PCI, respectively). For CA, the reference values for each parameter of radiation dose, defined as the round value of the third quartile of the overall distribution, were 36 Gy.cm² for P_{KA}, 498 mGy for Ka,r, and 6 min for FT. Corresponding references values for PCI were 78 Gy.cm², 1285 mGy and 15 min, respectively (Table 3). RL values estimated according to the 2016 ICRP recommendations, based on the 75th percentile of the medians of the 61 centres, are shown in Table 3. RLs calculated in unselected patients and in standard-sized (40th–60th percentiles of weight and BMI) patients of both sexes are shown in Table 4.

DISCUSSION

This multicentre national study collected data from 90 000 procedures performed in 61 centres by more than 200 interventional cardiologists. With the exception of the US CathPCI Registry, which collected only FT in over 3 million procedures[25], it is the largest multicentre study that gathered extensive data on patient radiation protection parameters. The data correspond to more than one-third of the annual activity of CI in the country and are, therefore, likely to be representative of the current practice of IC in France.

Depending on the source, RLs can be based on phantom studies, clinical examinations with a small number of standard patients, or clinical

Table 1. Baseline characteristics of interventional coronary procedures.

Centres, *n*	61
Procedures, *n*	93 451
Diagnostic CA, *n*	51 229
All PCI, *n*	42 222
Combined PCI*, *n*/No. (%)	35 479/42 222 (84.0)
Age, median (IQR), year	67.0 (58.0–77.0)
Male sex, *n*/No. (%)	65 275/92 948 (70.2)
BMI, median (IQR), kg/m^2	26.8 (24.2–30.1)
BMI >30 kg/m^2, *n*/No. (%)	23 306/86 698 (25.7)
Emergency procedure, *n*/No. (%)	11 765/91 696 (12.8)
Left ventriculography, *n*/No. (%)	16 757/93 451 (17.9)
Coronary graft opacification, *n*/No. (%)	3640/62 072 (5.9)
Radial approach, *n*/No. (%)	74 437/89 669 (83.0)
Clinical presentation	
Acute coronary syndrome, *n*/No. (%)	36 067/88 320 (40.8)
Stable or silent ischaemia, *n*/No. (%)	38 069/88 320 (43.1)
Non-ischaemic cardiopathy/others, *n*/No. (%)	14 184/88 320 (16.1)
Extent of coronary disease	
Non-significant lesion/Normal CA, *n*/No. (%)	25 389/84 909 (29.9)
Single-vessel disease, *n*/No. (%)	24 255/84 909 (28.6)
Two-vessel disease, *n*/No. (%)	15 323/84 909 (18.0)
Three-vessel disease, *n*/No. (%)	18 841/84 909 (22.0)
Number of treated lesions per PCI, mean ± SD	1.4 ± 0.7
Single-vessel PCI, *n*/No. (%)	21 620/32 224 (67.1)
Multi-vessel PCI, *n*/No. (%)	10 514/32 224 (32.6)
Number of implanted stents per PCI, mean ± SD	1.3 ± 0.8

*Combined PCI: PCI performed immediately after a CA in the same session.

Table 2. Radiation dose indicators for CA and PCI in the RAY'ACT-2 study.

		Diagnostic CA	All PCI	PCI alone	Combined
P_{KA}, Gy.cm^2	No.	48 547	40 026	6426	33 600
	Median (IQR)	20.8 (11.8–35.7)	45.2 (25.6–77.6)	38.0 (20.3–71.4)	46.4 (26.9–78.7)
Ka,r, mGy	No.	26 504	22 561	3410	19 151
	Median (IQR)	294 (164–498)	747 (421–1285)	668 (351–1285)	757 (433–1285)
FT, min	No.	43 863	36 293	5822	30 471
	Median (IQR)	3.3 (2.1–5.7)	9.8 (6.3–15.4)	9.8 (5.7–16.8)	9.8 (6.4–15.2)
NFs	No.	9120	7544	1519	6025
	Median (IQR)	404 (284–566)	676 (465–960)	537 (339–788)	710 (501–991)
NRs	No.	11 523	9726	1796	7930
	Median (IQR)	9 (8–11)	19 (14–25)	18 (12–25)	19 (15–25)

Combined = PCI performed immediately after diagnostic CA in the same procedure.
P_{KA} = kerma × area product (or dose × area product); Ka,r = total air kerma calculated at international reference point.

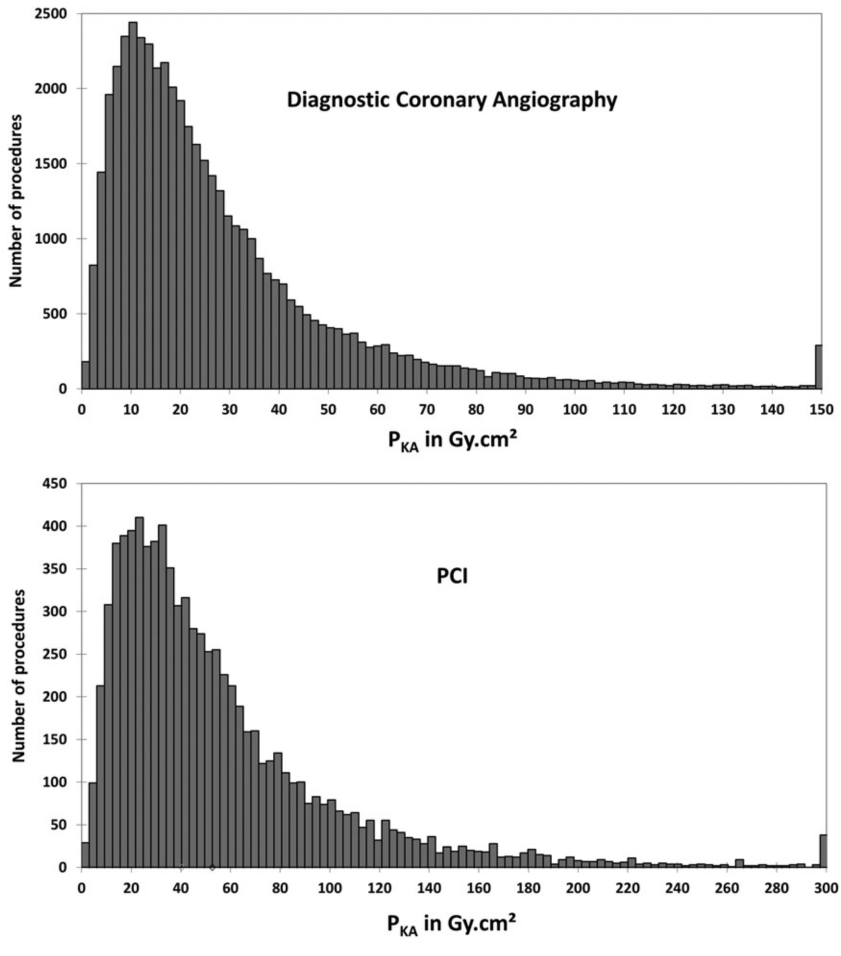

Figure 1. Distribution of air P_{KA} for diagnostic CA and PCI procedure.

Table 3. Estimation of RLs for radiation dose metrics using the rounded values of the 75th percentile of the total distribution, and the 75th centile of the medians in the participating facilities.

	75th percentile of total distribution	75th percentile of medians
CA		
P_{KA}, Gy.cm^2	38	26
Ka,r, mGy	522	353
FT, min	6	4
NFs	584	501
NRs	12	10
PCI		
P_{KA}, Gy.cm^2	80	60
Ka,r , mGy	1273	920
FT, min	15	11
NFs	957	666
NRs	25	21

P_{KA} = kerma × area product (or dose x area product); Ka,r = air kerma calculated at international reference point.

examinations of large numbers of patients. To establish RLs is difficult for fluoroscopically guided IC procedures, because there is a wide distribution of patient radiation doses for both diagnostic CA and PCI, even in the same procedure performed at the same institution[8, 9]. PCI are not standardised procedures, and radiation dose in IC is strongly affected by procedure complexity due to patient age and BMI, lesion characteristics, and disease severity. Consequently, the usual method for determination of DRLs is based on a restricted number of standardised procedures performed in average-sized patients[18, 20] and is of limited value for IC procedures[8]. The ICRP and the International Atomic Energy Agency proposed to use an index of procedure complexity to normalise radiation doses[8, 17]. RLs in PCI as a function of procedure complexity have been proposed[26]. In the majority of cases, as in the present study, this method cannot be used because all clinical and procedural data needed for the complexity index calculation are not available. In this study, however, RLs were estimated from all procedures within a single year that were performed at each institution, including complex procedures associated with the highest exposure, such as multivessel PCI and PCI of chronic coronary total occlusion.

Another approach to estimating RLs in fluoroscopically guided procedures is based on a dose audit[11, 27]. Dose audits consist of the radiation dose estimates for all of the cases of that procedure performed in a large number of facilities and provide a benchmark in the form of an ADS[9]. In the present study, the large amount of data collected in a large number of facilities allowed us to use this method. However, using this methodology, the institutions that contribute more to the overall data sample affect the suggested RLs, and the rest of the descriptive statistical parameters, more than the rest of the institutions. This is a limitation of the method, especially if there are large variations of the contribution of the institutions to the overall data sample. In the present study, the number of procedures by centre ranged from 700 to 3500, and there was no association between the volume of procedures and the median P_{KA} of the centre for CA and PCI.

Additionally, in order to test the robustness of ADS versus ‘conventional RLs’, results obtained in unselected patients were compared to RLs estimated in selected standardised-sized patients (the 20% of the study population of both sexes with average weight or BMI). The ADS values that were estimated in unselected patients were consistent with RLs estimated in average-sized patients, although slightly higher (Table 4). This small difference was also observed in previous studies, which showed a P_{KA} for CA and PCI of 45 and 111 Gy.cm², respectively, for patients in the weight range of 65–85 kg versus 49 and 122 Gy.cm², respectively, in patients regardless of weight[17]. Because the difference is small, we believe that RLs can accurately and more simply be estimated by the third quartile of the distribution in all included patients, regardless of their weight or BMI. Conversely, the large difference in radiation doses between males and females suggests that separate RL estimates for radiation parameters should be used for each sex.

RLs defined as the third quartile of the medians of the facilities are much lower than ADS and RLs calculated in standard-sized patients (Tables 3 and 4). Their values are approximately in the middle of the medians and the third quartiles of the distributions in all procedures. This difference is to be taken into account if one wishes to make comparisons of RLs.

The RLs estimated in the present study with ADS method are comparable to those of the few European studies[13, 15, 19], and lower than RLs from other national[9, 22] and international[17] studies using the same method of calculation (Table 5). Compared to the first RAY’ACT study conducted in 2011 on procedures performed in 2010, this study suggests a 20% decrease in the RLs for CA and PCI over a 3-y period. Although no formal statistical comparison is possible because the RLs are not estimated among the same centres or the same countries, the present results are likely to confirm a trend towards a reduction in RLs for IC procedures. This trend is observed even though the complexity of PCI is likely increasing, and may be explained by improvements in either the X-ray equipment or the use of optimisation tools by operators. The literature contains examples of significant decreases in patient

Table 4. RLs for radiation dose metrics estimated by the 75th percentile in unselected and standard-sized male and female patients.

		Males			Females		
		All	Weight-standardised*	BMI-standardised**	All	Weight-standardised*	BMI-standardised**
CA	No.	33 815	7212	6613	17 128	3371	3177
P_{KA}, Gy.cm^2	No.	32 027	6865	6266	16 260	3210	3001
	RL	40	38	37	27	24	25
Ka,r, mGy	No.	17 612	3804	3558	8805	1807	1599
	RL	559	522	516	372	332	336
FT, min	No.	28 872	6210	5677	14 757	2910	2711
	RL	6	6	6	5	5	5
NFs	No.	6325	1517	1366	2762	647	533
	RL	594	584	586	503	495	521
NRs	No.	7866	1851	1704	3640	799	701
	RL	11	12	11	11	10	11
PCI	No.	31 460	7065	6570	10 545	1796	2127
P_{KA}, Gy.cm^2	No.	29 818	6751	6252	10 008	1700	2027
	RL	82	80	81	63	56	61
Ka,r, mGy	No.	16 860	3856	3596	5641	1020	1155
	RL	1350	1273	1330	1050	918	994
FT, min	No.	26 959	6187	5705	9149	1567	1862
	RL	15	15	16	15	15	15
NFs	No.	5705	1457	1291	1831	370	396
	RL	983	957	990	878	848	842
NRs	No.	7505	1820	1762	2215	457	485
	RL	25	25	25	24	23	25

P_{KA} = kerma × area product (or dose × area product); Ka,r = total air kerma calculated at international reference point.
*Weight between 78 and 85 kg in males and 64 and 70 kg in females (corresponding to the 40th–60th percentiles of weight);
**BMI between 26.0 and 28.1 in males and 25.0 and 27.7 in females (corresponding to the 40th–60th percentiles of BMI).

radiation dose as a result of dose-reduction programs[28, 29] and the implementation of a culture of radiation safety[30]. Whether the trend towards a decrease in RLs is the result of improved practices of radiation protection and dose optimisation in a nationwide context is an important issue that deserves specific investigation.

The decrease in RLs and in average radiation exposure does not imply that there is a reduction in the deterministic risk for the patient. RLs are a marker of the stochastic risk and are not related to the deterministic risk, particularly the risk of radiation-induced skin injuries[8], which remains high in PCI for chronic total coronary occlusion and other selected interventional procedures[31].

This study has some limitations. The present results are likely representative of the current IC practice in France, but updated RLs are not generalisable to other countries, where CI practice may significantly differ. Thus, radial artery access was used in >80% of diagnostic CA and PCI in the present study whereas it is estimated to be used in only 6–12% of procedures worldwide[32]. Radial versus femoral access is generally associated with a higher patient radiation dose[32, 33]. However, this study was not designed to analyse the effect of radial versus femoral access. In contrast, left ventriculography was performed in <20% of procedures and this might have an impact on reduced radiation dose[29]. Lastly, P_{KA} was collected in 95% of procedures in routine practice, and Ka,r in only 50%. In Europe, P_{KA} is commonly used, and must be on the report of CA and PCI in France according to the regulations. In the USA, Ka,r is generally available, likely because the US Food and Drug Administration has required that all fluoroscopic units manufactured after mid-2006 display this parameter, whereas there is no requirement to display the P_{KA}[9].

In conclusion, this nationwide study has provided data on a number of CAs and PCIs. ADS as estimators of updated national RLs have been established from the total population and compared to RLs that were estimated in standardised-sized patients of both sexes. The results suggest a trend towards a time-course reduction in patient exposure during IC procedures. Further analyses are needed to confirm this trend and the possible relationships with improved practices of radiation protection.

Table 5. RL for P_{KA}, comparisons with values published in the literature.

Country (year of publication)	Number of centres	Number of CA	Number of PCI	Calculation method for RL	RL for diagnostic CA (Gy.cm²)	RL for PCI (Gy.cm²)
Europe (2003)[13]	6	600	600	75th p. of all values	57	94
Switzerland (2007)[14]	9	184	156	75th p. of all values	80	110/260*
Europe (2008)[15]	9	672	662	75th p. of all values	45	85
France (2008)[16]	17	496	317	75th p. of means of the centres	56	110
IAEA (2009)[17]	7	2265	1844	75th p. of all values	45	98/138*
U.K. (2009)[18]	110	—	—	75th p. of means of the rooms, patient weight 75–85 kg	29	50**
Belgium (2009)[19]	8	200	118	75th p. of all values	71	107
Ireland (2009)[20]	14	967	597	75th p. of all values	42	84/107*
Croatia (2010)[21]	4	138	151	75th p. of all values	32	72
Switzerland (2012)[22]	23	311	119	75th p. of all values	102	125
USA (2012)[9]	171	1326	672	75th p. of all values	83	193/199*
Greece (2013)[23]	26	2572	1899	75th p. of means of the centres	53	129
France (2014)[24]	44	31 067	25 356	75th p. of all values	45	86/96*
France (present study)	61	48 547	40 026	75th p. of all values	38	80

*RLs for PCI/combined CA+PCI, respectively; **single stent PCI.
P_{KA} = kerma × area product (or dose × area product); CA: diagnostic CA; 75th p.: 75th percentile.

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APPENDIX

STUDY SITES AND PARTICIPATING INVESTIGATORS

Aix en Provence: CH du Pays d'Aix (Bernard Jouve, Annick Bourdeloie, Claude Barnay); *Angoulême*: CH Général Girac-Angoulême (Nicolas Lucke, Robin Zelinsky, Pierre Wahl, Véronique Lucke); *Annecy*: CH de la Région d'Annecy (Lionel Mangin, Henri Bonnet, Stéphane Fol, Loïc Belle); *Antibes*: CH d'Antibes-Juan les Pins (Anne Bellemain-Appaix, Laurent Jacq, Sofiene Rekik, Francois Iannascoli); Ar*genteuil*: CH Victor Dupouy (Thierry Carrères, François Duclos, Chloé Durier); *Aulnay sous Bois*: CH Intercommunal Robert Ballanger (Jean-Michel Montely, Francois Walylo, Jean-Pierre Maroni); *Aurillac:* CH Henri Mondor (Manuel Font, Laurent Dutoit); *Auxerre*: CH d'Auxerre (François-Xavier Soto, Frédéric Schaad); *Avignon*: CH Henri Duffaut (Michel Pansieri, Marc Metge, Pierre Barnay, Jean-Lou Hirsh, Edith Larderet); *Bastia:* CH de Bastia (Ziad Boueri); *Boulogne sur Mer*: CH du Docteur Duchêne (Olivier Nugue); *Bourges*: CH Jacques Cœur (Thierry Déchery, Pierre Marcollet, Xavier Tabone); *Brive*: CH de Brive (Jean Paul Faure, Eric Fleurant); *Chambéry:* CH Metropole Savoie

(Vincent Hugon, Vincent Descotes-Genon, Stéphane Rias); *Chartres*: Hôpital Louis Pasteur (Franck Albert, Christophe Thuaire, Christophe Laure, Grégoire Range); *Colmar*: Hôpital Albert Schweitzer (Laszlo Levai, Michel Schneeberger, Antoine Verdun, Hervé Faltot); *Compiègne*: CH Général de Compiègne (Jérôme Clerc, Anne Luycx-Bore); *Corbeil-Essonnes*: CH Sud-Francilien Hôpital Gilles de Corbeil (Romain Berthier, Luc Doutrelant, Marcel Toussaint, Pascal Goube); *Dunkerque*: CH de Dunkerque (Olivier Tricot, Steve Werquin); *Eaubonne*: CH Intercommunal Eaubonne-Montmorency Hôpital Simone Veil (Gaëtan Karrillon, Francesca Sanguinetti, Victor Stratiev, Abdel Akesbi); *Gonesse*: CH de Gonesse (Mohamed Ghannem, Pierre Aubry, Serge Godard); *Grenoble:* Groupe Hospitalier Mutualiste (Benjamin Faurie, Mohamed Abdellaoui, Jacques Monsegu), *Haguenau*: CH de Haguenau (Pierre Leddet, Fabien de Poli , Philippe Couppie, Sabrina Uhry,Michel Hanssen); *La Roche Sur Yon*: CH Départemental Les Oudairies (Laurent Orion, Olivier Baron, Emmanuel Boiffard, Yoann Choplin, Jean-Olivier Nguyen-Khac); *La Rochelle*: CH Saint-Louis (Ludovic Meunier, Charlotte Trouillet, Yann Valy); *Lagny sur Marne-Jossigny*: CH de Lagny-Marne-la-Vallée (Simon Elhadad, Thierry Domniez, Rémi Foucher, Rémy Cohen, Anis Sfaxi); *Le Havre:* GH du Havre (Philippe Bonnet, Alexanre Canville, Emmanuel Lecluse); *Le Mans*: CH du Mans (François Vinchon, Thierry Labbé, Philippe Rosak); Le *Plessis-Robinson*: Centre Chirurgical Marie Lannelongue (Saïd Ghostine, Ryad Bourkaib, Philppe Brenot, Claude-Yves Angel); *Lens*: CH du Docteur Schaffner (Valérie Aumegeat, Mohamed Elmoujahid, Claudie Vandewalle, Max Pecheux); *Libourne*: CH Robert Boulin (Jean-Marie Perron, Jérome Lefevre); *Lorient*: CH Bretagne-Sud (Pierre Cazaux, Jean-Philippe Hacot, Pierre Khattar, Serge Baleynaud); *Mâcon:* CH Les Chanaux (François Cuilleret, Patrick Bert-Marcaz, Olivier Wittenberg, Arnaud Ribier); *Metz*: CH Régional Notre-Dame de Bon Secours (Khalifé Khalifé, Michel Boursier, Marwan Yassine); *Mont de Marsan*: CH de Mont de Marsan, Hôpital Layne (Pierre Rougier, Akil Hassan) ; *Montfermeil*: CH Intercommunal Le Raincy-Montfermeil (Olivier Nallet, Jean-Baptiste Estève, Simon Cattan); *Montreuil:* CH de Montreuil (Albert Boccara); *Mulhouse*: CH Emile Müller (Laurent Jacquemin, Olivier Roth, Jean-Yves Wiedemann); *Nevers*: Hôpital Pierre Bérégovoy (Jacques Ballout); *Niort*: CH de Niort (Guillaume Lucas, Mohamed Benmakhlouf); *Nouméa*: Centre Hospitalier territorial Gaston Bourret (Benjamin Bonnet, Rachid Elbeghiti, Corinne Braunstein); *Paris*: Hôpital d'Instruction des Armées du Val De Grâce (Franck Barbou, Patrick Schiano); *Paris*: Institut Mutualiste Montsouris (Alain Dibie, Christophe Caussin, Nicolas Amabile); *Paris*: Hôpital Saint Joseph (Romain Cador, Philippe Durand); *Perpignan*: CH de Perpignan (Frédéric Tardosz, Pierre Sultan); *Poissy*: CH Intercommunal de Poissy-Saint-Germain (Xavier Marchand, Dina Zannier, David Berville); *Pontoise*: CH René Dubos (François Funck, Nils Guillard, Véronique Decalf); *Quimper*: CH Intercommunal de Cornouaille (Gilles Rouault, Thierry Joseph, Daniel Garnier); *Saint-Brieuc*: CH Yves Le Foll (Régis Delaunay, Amer Zabalawi, Benoit Moquet); *Saint-Malo*: CH de Saint-Malo (Philippe Deutsch, Antoine Rialan); *Saint-Nazaire*: CH Général de Saint-Nazaire (Loïc Genet, Jacques Denis), Polyclinique de l'Europe (Yann Chalet); *Saint Quentin*: CH Général de Saint-Quentin (Sébastien Duval, Sandie Spagnol, Eric Colpart); *Suresnes*: Hôpital Foch (Faride Harfouche, Philippe Goy, Hakim Benamer); *Toulon*: Hôpital d'Instruction des Armées Sainte-Anne (Raphael Poyet, Gilles Cellarier); *Troyes*: CH de Troyes (Laurent Chapoutot, Raed Saad al Deen, Bruno Mailler); *Valence*: CH de Valence (Christophe Bretelle, Stanislas Champin, Jean-Baptiste Pichard, Philippe Chapon); *Valenciennes*: CH Jean Bernard (David Houpe, Darius Azami, Christophe Camier, Didier Vilarem); *Vannes*: CH Bretagne Atlantique (Emmanuelle Filippi-Codaccioni, Alain Kermarrec, Christophe Le Ray); *Versailles-Le Chesnay*: CH de Versailles, Hôpital André Mignot (Jean-Louis Georges, Géraldine Gibault-Genty, Elodie Blicq, Bernard Livarek); *Vichy-Moulins*: CH Jacques Lacarin de Vichy (Xavier Marcaggi, Gabriel Bitar, Martin Hevin); *Villeneuve-St-Georges*: CH Intercommunal de Villeneuve-St-Georges (Emmanuel Salengro, Fawaz Nassar, Alireza Samadi, Pascal Wyart, Dominique Dumant).