X-ray management in electrophysiology: a survey of the Italian Association of Arrhythmology and Cardiac Pacing (AIAC)

X-ray management in electrophysiology: a survey of the Italian Association of Arrhythmology and Cardiac Pacing (AIAC)

Matteo Anselmino[1], Andrea Ballatore[1], Marzia Giaccardi[2], Alessia Agresta[3], Enrico Chieffo[4], Roberto Floris[5], Marco Racheli[6], Marco Scaglione[7], Michela Casella[8], Massimiliano Maines[9], Massimiliano Marini[10], Gaetano Maria De Ferrari[1], Roberto De Ponti[11], Maurizio Del Greco[9].

[1] Division of Cardiology, "Città della Salute e della Scienza di Torino" Hospital, Department of Medical Sciences, University of Turin, Italy

[2] Cardiology and Electrophysiology Unit, Department of Medicine, "Santa Maria Nuova" Hospital, Florence, Italy

[3] Clinica Mediterranea, Via Orazio 2, 80122, Naples, Italy

[4] Institute of Cardiology, Maggiore Hospital, Crema, Italy

[5] Cardiologo all'Ospedale di Nostra Signora di Bonaria, Cagliari, Italy

[6] Cardiology Division, Ospedale St Andrea, La Spezia, Italy

[7] Division of Cardiology, "Cardinal Massaia" Hospital, Asti, Italy

[8] Cardiology and Arrhythmology Clinic, Marche Polytechnic University, University Hospital "Ospedali Riuniti Umberto I - Lancisi - Salesi", Via Conca 71, Ancona, Italy

[9] Divisione di Cardiologia, Ospedale S. Maria del Carmine, Rovereto, Italy

[10] Department of Cardiology, S. Chiara Hospital, Trento

[11] Department of Heart and Vessels, Ospedale di Circolo-University of Insubria, Varese, Italy

Total word count: 2023 words, 4 figures, 1 table, 25 references

Abstract word count: 251 words

Corresponding author:

Matteo Anselmino, MD PhD Associate Professor

Address: corso Dogliotti 14, 10126, Torino, Italy

Phone number: (39)-0116709598; fax: (39)-0112369598;

email address: matteo.anselmino@unito.it

Abstract

Aims. Radiation use in medicine has significantly increased over the last decade, and Cardiologists are among the specialists most responsible for X-ray exposure. The present study investigates a broad range of aspects, from specific European Union directives to general practical principles, related to radiation management among a National cohort of Cardiologists.

Methods and results. A voluntary 31 questions survey was run on the Italian Arrhythmology and Pacing Society (AIAC) website. From June 2019 to January 2020, 125 cardiologists, routinely performing interventional electrophysiology, participated at the survey. Eighty-seven (70.2%) participants are aware of the recent European Directive (Euratom 2013/59), however only 35 (28.2%) declare to have read the document in details. Ninety-six (77.4%) participants register the dose delivered to the patient in each procedure, in 66.1% of the cases both as fluoroscopy time and dose area product. Years of exposition (p=0.009) and working in a center performing pediatric procedures (p=0.021) related to greater degree of X-ray equipment optimization. The majority of participants (72, 58.1%) did not recently attend radioprotection courses. The latter related to increased awareness of techniques to reduce radiation exposure (96% vs 81%, p=0.022), registration of the delivered dose in each procedure (92% vs 67%, p=0.009), and X-ray equipment optimization (50% vs 36%, p=0.006).

Conclusion. Italian interventional cardiologists show an acceptable level of radiation awareness and knowledge of updated European directives. However, there is clear space for improvement. Comparison to other health professionals, both at National and International levels, is needed to pursue proper X-ray management and protect public health.

Keywords: Survey; radiation risk; radioprotection; cardiac electrophysiology.

Introduction

X-rays are classified as class I carcinogens [1], and the mechanisms explaining their effects are well known. As carcinogenesis due to radiation exposure is a stochastic process, a safety threshold does not exist, being even low doses of X-rays possible cause of malignancies [2]. In addition, radiation exposure induces detrimental effects on several organs, as the crystallinus, brain and endocrine/reproductive system, provoking cataract, reproductive disorders and neurodegenerative effects [3–6].

Radiation use in medicine has significantly increased over the last decade, and, excluding Radiotherapists, Cardiologists are the specialists responsible for the majority of X-ray exposure (about 40%) [7].

In the attempt to optimize radiological hazard management, driven by the European Council's Regulation update (Euratom 2013/59), cardiological societies have issued guidelines and recommendations. Overall, the principles of exposure optimization and justification emerge as guiding, highlighting the central role of the "3 A's": Audit, Awareness, and Appropriateness [8–11].

The present study describes the results of a web-based survey proposed to Italian interventional electrophysiologists by a Working Group of the Italian Association of Arrhythmology and Cardiac Pacing Society (Associazione Italiana di Aritmologia e Cardiostimolazione, AIAC) to investigate a broad range of aspects, from specific European Union directives to general practical principles, related to radiation management.

Methods

A voluntary survey including 31 questions and open or multiple-choice answers was run on the AIAC website (www.AIAC.it). Requirements to participate in the survey were registration to National Society's website and approval of the specific privacy data policy (according to article 13, 196/2003 of the Italian Regulation and 13, 679/2016 of the European Union normative).

The questionnaire was designed by MA and MDG, on behalf of the "Area Raggi Zero", an official AIAC's Working Group (https://aiac.it/attivita/aree-task-force/aree-aiac/area-raggi-zero/), to investigate global perception of X-ray exposure hazard, knowledge of and adherence to current normative prescriptions among interventional electrophysiologists members of the Society.

The complete list of questions is detailed in the Appendix Table S1. The survey was online from June 2019 to January 2020.

Statistical analysis

Continuous variables are reported as mean and standard deviation (SD), whereas categorical variables as number of cases and percentage (± the 95% margin of error). For stratification in categorical variables, age, years of exposition and number of procedures as first practitioner, were classified into median and quartiles (IQR). Categorical variables were compared by contingency tables and chi-square test. Continuous variables were compared within strata by ANOVA analysis or t-test. All tests of significance were two tailed and a $p<0.05$ was considered statistically significant. Analysis was performed using R V.4.0.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Across 15 Italian regions, 125 Cardiologists, specialized in interventional electrophysiology, participated at the survey (Figure 1). The response rate to the survey, according to the 2017 AIAC census [12], was 14% (125 cardiologist out of the 910 included in this census), representative of 37% (64 out of the 174) of the Italian centers performing interventional electrophysiology. Participants demographic characteristics are reported in Table 1: 47 (37.9±8.5%) are employed in centers where 100-200 electrophysiological procedures are performed each year, 52 (41.9 ± 8.7%) in centers performing also pediatric procedures. Complete details on answers to the 31 questions of the survey are reported in Table S1 in the Appendix.

Concerning background knowledge on the topic, 20 (18.5 ±7.3%) of the participants state to not recognize any of the proposed international literature on X-rays clinical hazards, and 16 (12.9 ± 5.9%) declare not to be aware of available techniques to minimize radiation use in the electrophysiological laboratory.

Eighty-seven (70.2 ± 8.1%) participants are aware of the recent European Directive (Euratom 2013/59), however only 35 (28.2 ± 7.9%) have read it in details. The majority of participants (72, 58.1 ± 8.7%) did not recently attend radioprotection courses, in 46.8 ± 8.8% of the cases due to lack of proposals by their institution.

Three out of four participants (96, 77.4 ± 7.4%) register the delivered dose to the patient in each procedure, in 66.1 ± 8.3% of the cases both as fluoroscopy time and dose area product (DAP); a similar quote of participants is aware of his own exposition dose during the previous year (94, 75.8 ± 7.5%).

The first operator is commonly (109, 87.9 ± 5.7%) in charge of controlling X-rays delivery; a radiology technician is always available for 50 (40.3 ± 8.6%) participants.

X-ray equipment is regularly optimized for 41.9 ± 8.7% of the participants (for 21.8 ±7.3% on a case-by-case basis); for 11.3 ± 5.6% the equipment is never optimized.

Among the interviewed electrophysiologists, only 14 (11.3 ± 5.6%) do not have an electroanatomical mapping system available. When available, the majority uses them for ablation procedures of a comprehensive set of arrhythmias: as an example, 85.8 ± 6.4% of the participants perform more than 50% atrial fibrillation (AF) ablations with electroanatomical mapping systems (full details in Figure S1, Appendix). The economic burden is the most common reason (35, 34.0 ± 9.1%) for not routinely using these systems.

Participant's age, gender, years of exposition, number of procedures per year and involvement in pediatric procedures were tested at univariate analysis in search of inference with the given answers (Table S2, Appendix).

Participant's age (median 43, IQR 36-51) relates to an increased awareness of the previous year's exposure ($p=0.023$). Years of exposition (median 10, IQR 5-20), and working in a center performing pediatric procedures are associated with a greater degree of X-ray equipment optimization, at least periodically (56% if > 20 years of exposition vs 23% if ≤5 years of exposition, $p=0.009$, and 52% vs 35%, $p=0.021$, in centers performing or not pediatric procedures respectively; Figure 2). The presence of a radiology technician did not influence the rate of equipment optimization ($p=0.246$) or the recording of the dose delivered to the patient ($p=0.992$). Working in a center performing pediatric procedures relates to availability of electroanatomical mapping systems (0% vs 19% with no mapping systems, $p<0.001$), and their differential use among the different procedures ($p=0.014$): participants working in centers performing pediatric procedures, more commonly use mapping systems for all procedures, including device implantations (25% vs 7%); conversely, none of them perform biventricular pacing implantations exclusively (0% vs 13%).

Similarly, number of procedures as first practitioner in the previous year is associated with periodical X-ray equipment optimization (53% if > 125 procedures per year vs 38% if ≤ 50 procedures per year, p=0.017), and the differential use of mapping systems among the different procedures: practitioners performing a higher number of procedures per year (≥ 126, 81-125, 51-80) more frequently use mapping systems in high percentage of procedures (76-100%) for AF and atypical atrial flutter (88% vs 85% vs 79% vs 52%, p=0.049), for AT (88% vs 92% vs 79% vs 48%, p=0.010), and for VT (92% vs 93% vs 75% vs 48%, p=0.002); compared to their colleagues performing ≤ 50 procedures per year, respectively (Figure 3). In addition, center's volume influences operator's knowledge of techniques to minimize radiation use: the respondents who declare not to be aware of any technique decreased with the increase of procedures per year (50 and 0% for <50, and >500 procedures per center per year, respectively; p = 0.009; Figure S2, Appendix).

Finally, attendance of radioprotection courses, related to increased awareness of techniques to reduce radiation exposure (96% vs 81%, p=0.022), registration of the delivered dose in each procedure (92% vs 67%, p=0.009), and X-ray equipment optimization (50% vs 36%, p=0.006; Figure 4).

Discussion

The extensive X-ray use by Cardiologists is a matter of fact, to increase knowledge on radiological hazard management is the community's responsibility. The present study, performed among Italian Cardiologists routinely performing interventional electrophysiology, highlights the strong motivation of AIAC to fulfil the audit, awareness, and appropriateness principles, with the final aim to achieve proper X-ray management and improve social health.

The response rate of this survey, albeit lower than the average reported by surveys performed among healthcare professionals [13], is in line with that of voluntary web-based surveys performed among physicians [14]. In addition, participants to the survey are representative of more than one third of the Italian centers performing interventional electrophysiology.

The survey inquired a broad range of aspects, from specific European Union directives (e.g. participation to radioprotection courses, as prescribed in article 14 of the Euratom 2013/59 normative), to general principles related to practical radiation management (e.g. frequency of X-ray equipment optimization).

Several encouraging features emerge from the survey. The majority of participants (77%) register the delivered dose in all procedures, commonly (66%) both as fluoroscopy time, than as DAP, a more precise parameter of radiation delivery, better correlating to the scattered radiation received by the personnel in the lab. Proficient dose registration is a known factor increasing radiation awareness in all the staff [15].

Similarly, Italian interventional electrophysiologists declare adequate knowledge of available radiation reduction techniques and relative literature. Of note, three papers [16–18] inspired about 40% of participants. More than half of the participants of the survey reported that they optimize the X-ray equipment periodically or on a case-by-case basis, another highly relevant strategy to decrease X-ray exposure [15]. Eventually, availability of electroanatomical

mapping systems to guide non-fluoroscopic catheter manipulation, a highly effective approach to minimize X-ray exposure [16,18–22], is wide.

On the other hand, there surely is space for improvement. Radioprotection courses appear largely unavailable (46.8%), and about one third of the participants are unaware of the latest update of the European radioprotection regulations. The positive effect of radioprotection courses on radiation awareness [23] is confirmed by the present study. Participants who recently participated to radioprotection classes declared superior knowledge of radiation reduction techniques, higher compliance in recording delivered dose in each procedure and more frequent X-ray equipment optimization (Figure 4). Electroanatomic mapping systems, albeit having demonstrated to be effective in reducing radiation delivery [24], do not automatically translate into a reduction of X-ray exposure or in the increase of radiation awareness and knowledge. Their use, in any case, needs to be accompanied with radiation use mitigation [15], the cornerstone of improved radiation management.

Of note, the presence of a radiology technician, known to influence radiation delivery (e.g. by optimizing collimation and view projections) [15,25] was lacking for nearly half (46%) of the participants. In any case, based on the present survey, this did not seem to influence the rate of equipment optimization, nor the recording of the dose delivered to the patient.

Altogether, the results emerging from the survey indicate that interventional electrophysiologists performing pediatric procedures, most likely due to the higher detrimental effects in this subgroup [8], are more sensitive to radiation harm and more commonly optimize X-ray equipment or use electroanatomical mapping systems.

Limitations

This work presents some limitations. First, the number of participants is limited; this may

have entailed statistical under-powering and must be taken into account for data interpretation. Another limitation stems from the design of the study: as participation to the web-based survey was voluntary, a selection bias may be present, with the most radiation-sensitive practitioners more represented. Finally, the aim of the survey was to investigate the overall awareness of the European and Societies' guidelines among a National cohort of Cardiologists routinely performing interventional electrophysiology. Direct queries assessing if recommendations are actually followed, that inevitably would directly or indirectly involve other subjects or institutions than those participating to the survey, were, in fact, expressly avoided. Information on whether specific indications are followed (e.g. correct indication of supervised or appropriate workplace radiological surveillance) do, therefore, not emerge from the survey. Eventually, although European Council Regulation, guidelines and recommendations are shared with other European countries, the study is representative of the Italian situation, and, transposition may widely diverge.

Conclusion

Italian interventional electrophysiologist show an acceptable level of radiation awareness and knowledge of updated European directives. However, there is clear space for improvement, as a significant percentage of participants, for example, did not recently attend radioprotection courses. Comparison to other health professionals (e.g. Radiologists, Radiotherapists) both at National and International levels is needed to fulfil the audit, awareness, and appropriateness principles, and pursue proper X-ray management to protect public health.

Acknowledgements

We acknowledge the AIAC Ricerca Investigators who participated in this survey, in particular the following Centers (exactly as indicated by the participant, when reported) by Region (in alphabetical order):

Calabria: Istituto Tricarico Rosano, Belvedere Marittimo (Cosenza); Campania: AORN Moscati, Avellino; Clinica Montevergine, Mercogliano (Avellino); Clinica San Michele, Maddaloni (Caserta); AUP Federico II, Napoli; Emilia-Romagna: Ospedale Bufalini, Cesena; AOU Parma; Ospedale Maggiore - AUSL città di Bologna; Ospedale Infermi - ASL Romagna, Rimini; Friuli Venezia Giulia: Ospedale di Gorizia; Presidio Ospedaliero di Pordenone; Presidio Ospedaliero "Santa Maria della Misericordia", Udine; Lazio: Policlinico Campus Bio-Medico, Roma; Azienda Ospedaliera Sant'Andrea, Roma; Ospedale Sant'Eugenio, Roma; Policlinico Universitario Umberto I, Roma; Liguria: Ospedale Padre Antero Micone, Genova; SC Cardiologia – SSA Aritmologia Clinica e Interventistica, Imperia; ASL 3 Genovese Villa Scassi, Genova; Ospedale S Paolo, Savona; Cardiologia-UU; Lombardia: Ospedale Bolognini - ASST Bergamo Est, Seriate (Bergamo); Ospedale Luigi Sacco - ASST FBF Sacco, Milano; Ospedale Maggiore di Crema – ASST Crema (Cremona); Centro Cardiologico IRCCS, Milano; Casa di cura Poliambulanza, Brescia; ASST Papa Giovanni XXIII, Bergamo; Istituto Auxologico Italiano - Ospedale S. Luca, Milano; Ospedale di Circolo-Università dell'Insubria, Varese; Marche: Azienda Ospedaliera Universitaria Ospedali Riuniti, Ancona; Piemonte: AO Sant'Andrea, Vercelli; SS Elettrofisiologia AOU Maggiore della Carità, Novara; Cardiologia Ospedale Maria Vittoria, Torino; Ospedale Cardinal Massaia, Asti; Puglia: Azienda Ospedaliera "Cardinale Giovanni Panico", Tricase (Lecce); Ospedale "Miulli", Acquaviva delle Fonti (Bari); Ospedale "SS. Annunziata", Taranto; ECL, Ospedale "Vito Fazzi" ASL Lecce; Sardegna: Ospedale "Nostra Signora di

Bonaria", San Gavino Monreale (Provincia del Sud Sardegna); Ospedale S. Michele, Cagliari; Ospedale "San Francesco", Nuoro; Clinica Cardiologica-UTIC – Policlinico "D. Casula", Monserrato – Cagliari; Ospedale SS. Trinità – Cardiologia, Cagliari; Ospedale "Giovanni Paolo II", Olbia; Sicilia: ARNAS Ospedale Civico, Palermo; Centro Neurolesi "Bonino Pulejo", Messina; Toscana: UOS di Cardiologia ed Elettrofsiologia Firenze 1 Azienda sanitaria Firenze; Azienda USL Toscana Centro; Policlinico Santa Maria delle Scotte, Siena; UOC Cardiologia Arezzo Dipartimento Cardiovascolare e Neurologico ASL Toscana Sud Est, Arezzo; Ospedale Santa Maria alla Gruccia, Montevarchi (Arezzo); Trentino Alto Adige: Ospedale S.M. del Carmine, Rovereto (Trento); Ospedale Regionale di Bolzano; Ospedale S. Chiara, Trento; Veneto: Ospedale San Bortolo, Vicenza; Ospedale Mater Salutis, Legnago (Verona); Santa Maria dei Battuti, Conegliano (Treviso); Ospedale Santa Maria della Misericordia, Rovigo; Azienda Ospedaliera di Padova; Ospedale Fra Castoro, San Bonifacio (Verona); Ospedale Civile di Portogruaro, Portogruaro (Venezia); Presidio Ospedaliero di Camposampiero, (Padova); Presidio Ospedaliero Santa Maria del Prato, Feltre (Belluno); Ospedale di Mirano, Mirano (Venezia).

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

Conflict of interest

None declared.

Funding

No funding was specifically received for this work.

References

[1] List of Classifications – IARC Monographs on the Identification of Carcinogenic Hazards to Humans n.d. https://monographs.iarc.fr/list-of-classifications (accessed May 7, 2020).

[2] Council NR. Health risks from exposure to low levels of ionizing radiation: BEIR VII Phase 2. National Academies Press; 2006. https://doi.org/10.17226/11340.

[3] Sarkozy A, De Potter T, Heidbuchel H, Ernst S, Kosiuk J, Vano E, et al. Occupational radiation exposure in the electrophysiology laboratory with a focus on personnel with reproductive potential and during pregnancy: A European Heart Rhythm Association (EHRA) consensus document endorsed by the Heart Rhythm Society (HRS). Europace 2017;19:1909–22. https://doi.org/10.1093/europace/eux252.

[4] Andreassi MG, Piccaluga E, Guagliumi G, Del Greco M, Gaita F, Picano E. Occupational health risks in cardiac catheterization laboratory workers. Circ Cardiovasc Interv 2016;9:1–8. https://doi.org/10.1161/CIRCINTERVENTIONS.115.003273.

[5] Borghini A, Vecoli C, Mercuri A, Carpeggiani C, Piccaluga E, Guagliumi G, et al. Low-Dose Exposure to Ionizing Radiation Deregulates the Brain-Specific MicroRNA-134 in Interventional Cardiologists. Circulation 2017;136:2516–8. https://doi.org/10.1161/CIRCULATIONAHA.117.031251.

[6] Hall P. Effect of low doses of ionising radiation in infancy on cognitive function in adulthood: Swedish population based cohort study. BMJ 2004;328:19–0. https://doi.org/10.1136/bmj.328.7430.19.

[7] Picano E, Vano E. The Radiation Issue in Cardiology: the time for action is now.

Cardiovasc Ultrasound 2011;9:35. https://doi.org/10.1186/1476-7120-9-35.

[8] Picano E, Vano E, Rehani MM, Cuocolo A, Mont L, Bodi V, et al. The appropriate and justified use of medical radiation in cardiovascular imaging: a position document of the ESC Associations of Cardiovascular Imaging, Percutaneous Cardiovascular Interventions and Electrophysiology. Eur Heart J 2014;35:665–72. https://doi.org/10.1093/eurheartj/eht394.

[9] Fazel R, Gerber TC, Balter S, Brenner DJ, Carr JJ, Cerqueira MD, et al. Approaches to Enhancing Radiation Safety in Cardiovascular Imaging. Circulation 2014;130:1730–48. https://doi.org/10.1161/CIR.0000000000000048.

[10] Triple-A Investment in Patients' Health | IAEA n.d. https://www.iaea.org/newscenter/news/triple-investment-patients-health (accessed May 7, 2020).

[11] Giaccardi M, Anselmino M, Del Greco M, Mascia G, Paoletti Perini A, Mascia P, et al. Radiation awareness in an Italian multispecialist sample assessed with a web-based survey. Acta Cardiol 2020:1–5. https://doi.org/10.1080/00015385.2020.1733303.

[12] Censimento AIAC 2017 | AIAC n.d. https://aiac.it/attivita/censimenti/censimento-2017/ (accessed March 26, 2021).

[13] Cho YI, Johnson TP, VanGeest JB. Enhancing Surveys of Health Care Professionals: A Meta-Analysis of Techniques to Improve Response. Eval Heal Prof 2013;36:382–407. https://doi.org/10.1177/0163278713496425.

[14] Dykema J, Jones NR, Piché T, Stevenson J. Surveying Clinicians by Web: Current Issues in Design and Administration. Eval Heal Prof 2013;36:352–81.

https://doi.org/10.1177/0163278713496630.

[15] Heidbuchel H, Wittkampf FHM, Vano E, Ernst S, Schilling R, Picano E, et al. Practical ways to reduce radiation dose for patients and staff during device implantations and electrophysiological procedures. EP Eur 2014;16:946–64. https://doi.org/10.1093/europace/eut409.

[16] Gaita F, Guerra PG, Battaglia A, Anselmino M. The dream of near-zero X-rays ablation comes true. Eur Heart J 2016;37:2749–55. https://doi.org/10.1093/eurheartj/ehw223.

[17] Casella M, Dello Russo A, Pelargonio G, Del Greco M, Zingarini G, Piacenti M, et al. Near zerO fluoroscopic exPosure during catheter ablAtion of supRavenTricular arrhYthmias: the NO-PARTY multicentre randomized trial. Europace 2016;18:1565–72. https://doi.org/10.1093/europace/euv344.

[18] Scaglione M, Biasco L, Caponi D, Anselmino M, Negro A, Di Donna P, et al. Visualization of multiple catheters with electroanatomical mapping reduces X-ray exposure during atrial fibrillation ablation. Europace 2011;13:955–62. https://doi.org/10.1093/europace/eur062.

[19] Bulava A, Hanis J, Eisenberger M. Catheter Ablation of Atrial Fibrillation Using Zero-Fluoroscopy Technique: A Randomized Trial. PACE - Pacing Clin Electrophysiol 2015;38:797–806. https://doi.org/10.1111/pace.12634.

[20] Anselmino M, Sillano D, Casolati D, Ferraris F, Scaglione M, Gaita F. A new electrophysiology era: Zero fluoroscopy. J Cardiovasc Med 2013;14:221–7. https://doi.org/10.2459/JCM.0b013e3283536555.

[21] Scaglione M, Ebrille E, Caponi D, Battaglia A, Di Donna P, Anselmino M, et al. Zero-fluoroscopy atrial fibrillation ablation in the presence of a patent foramen ovale: a multicentre experience. J Cardiovasc Med 2020;21:292–8. https://doi.org/10.2459/JCM.0000000000000943.

[22] Del Greco M, Maines M, Marini M, Colella A, Zecchin M, Vitali-Serdoz L, et al. Three-Dimensional Electroanatomic Mapping System-Enhanced Cardiac Resynchronization Therapy Device Implantation: Results From a Multicenter Registry. J Cardiovasc Electrophysiol 2017;28:85–93. https://doi.org/10.1111/jce.13120.

[23] Carpeggiani C, Kraft G, Caramella D, Semelka R, Picano E. Radioprotection (un)awareness in cardiologists, and how to improve it. Int J Cardiovasc Imaging 2012;28:1369–74. https://doi.org/10.1007/s10554-011-9937-8.

[24] Casella M, Dello Russo A, Russo E, Catto V, Pizzamiglio F, Zucchetti M, et al. X-Ray Exposure in Cardiac Electrophysiology: A Retrospective Analysis in 8150 Patients Over 7 Years of Activity in a Modern, Large-Volume Laboratory. J Am Heart Assoc 2018;7. https://doi.org/10.1161/JAHA.117.008233.

[25] Perisinakis K, Damilakis J, Theocharopoulos N, Manios E, Vardas P, Gourtsoyiannis N. Accurate assessment of patient effective radiation dose and associated detriment risk from radiofrequency catheter ablation procedures. Circulation 2001;104:58–62. https://doi.org/10.1161/hc2601.091710.

Figures

Figure 1. Italian interventional electrophysiologists participating to the web-based survey stratified by Region.

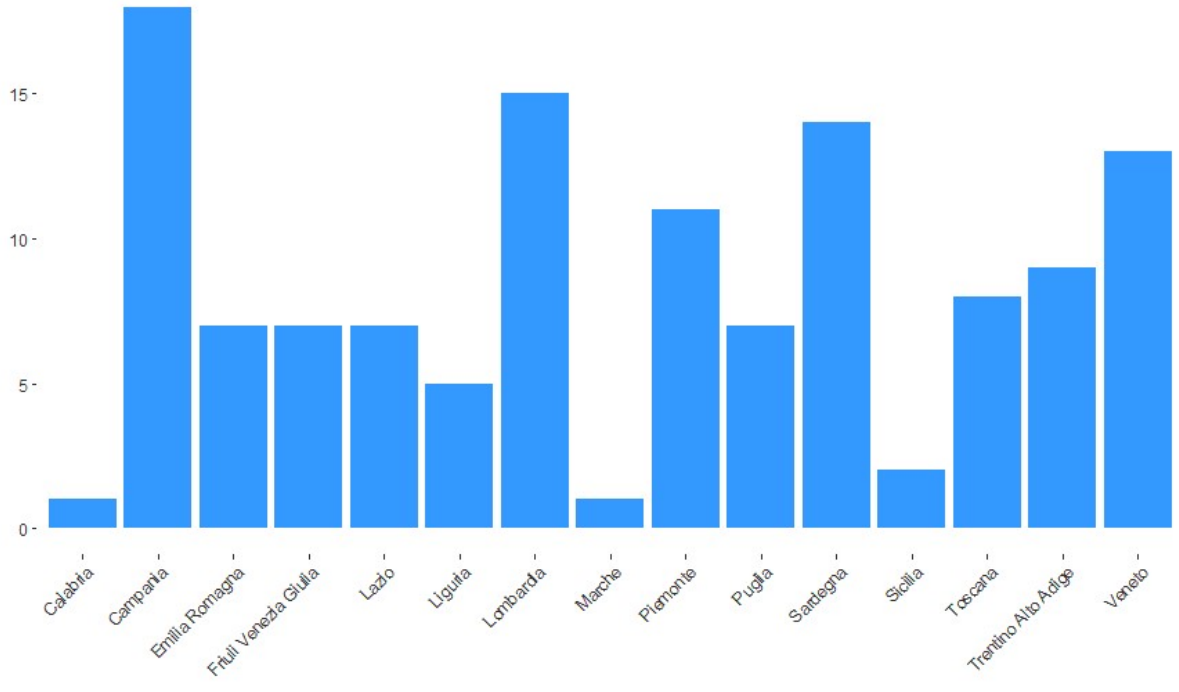


Figure 2. Participants working in centers performing (n=52) or not (n=72) pediatric procedures and X-ray equipment optimization (for the purpose of the figure the answers "Yes, case by case" and "Yes, periodically" have been merged in "Yes"; the answers "No" and "I do not know" have been merged in "No").

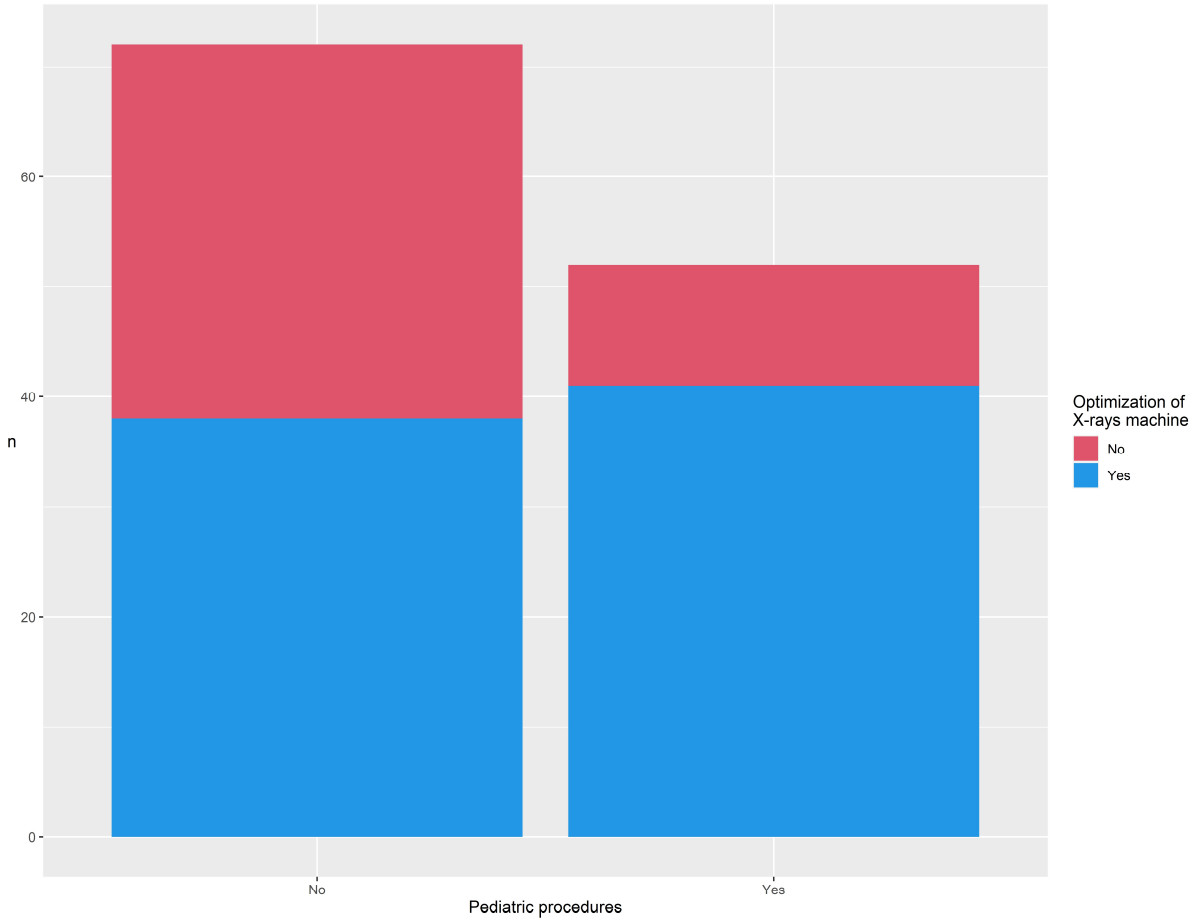


Figure 3. Number of procedures performed as first operator and use of mapping systems for at least 75% of AF (a), atrial tachycardia (b) and ventricular tachycardia (c) ablation procedures.

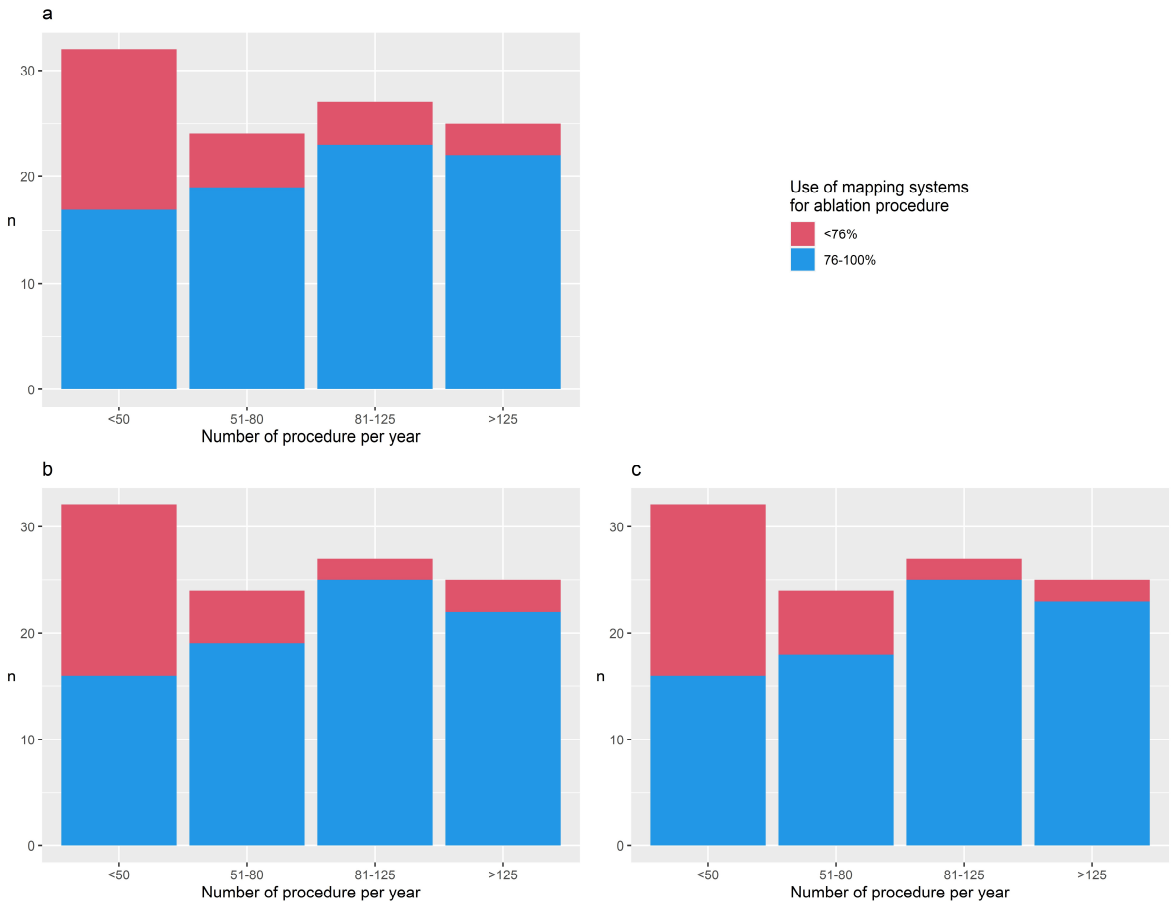
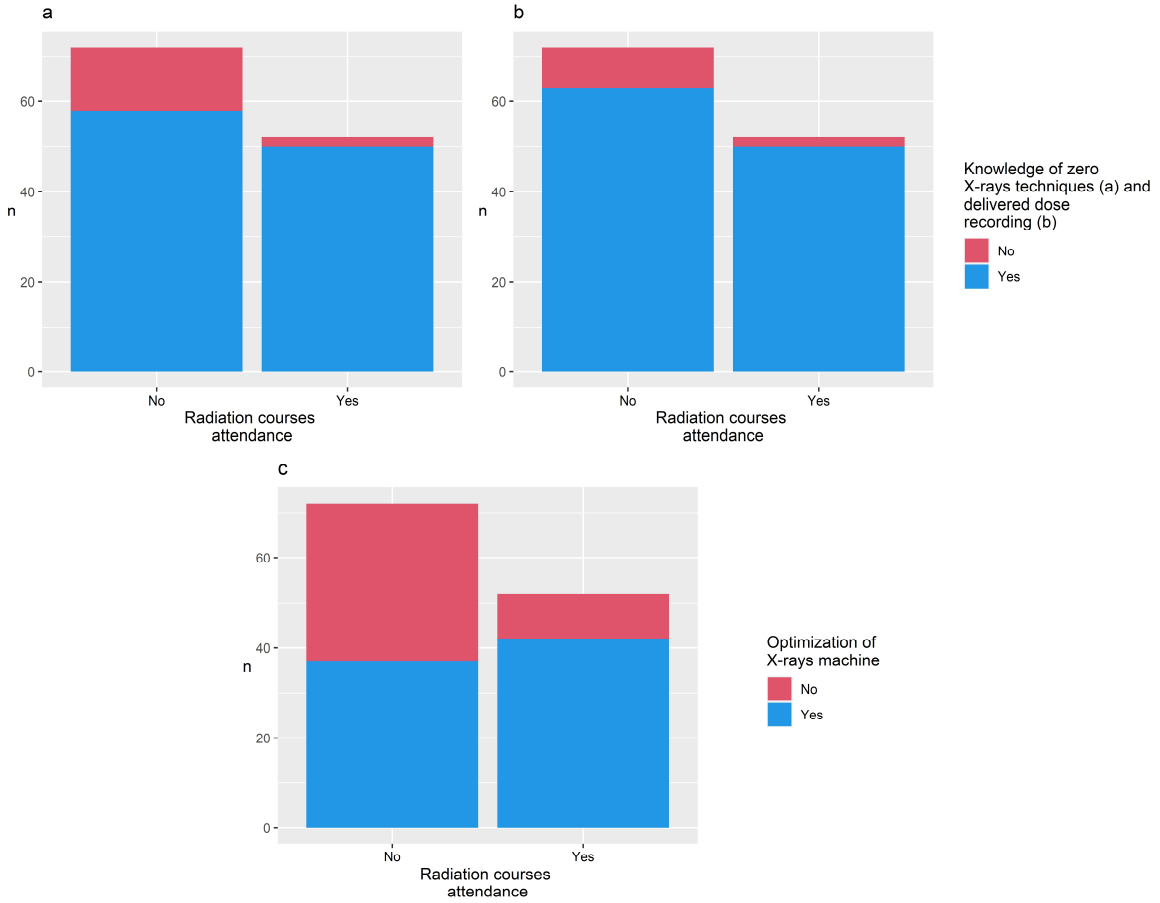


Figure 4. Radioprotection courses attendance (Yes=52, No=72) stratified by awareness of techniques to reduce radiation exposure (a), recording of delivered radiation dose in each procedure (b), and regular X-ray equipment optimization (c). For the purpose of the figure, in panel "b", the answers "Yes", "Yes, not in every patient" and "Yes, but it is not stored" have been merged in "Yes"; in panel "c", the answers "Yes, case by case" and "Yes, periodically" have been merged in "Yes"; the answers "No" and "I do not know" have been merged in "No".



Tables

Table 1. Principal participant's demographics characteristics (mean ±SD, or count and percentage).

Variable	
Gender, male	94 (75.2%)
Age (years)	44.1 (±9.59)
Total years of X-ray exposure	14.1 (±15.96)
Number of procedures as first operator per year	106.0 (±89.09)