



# 5 Use of fluoroscopy in clinical electrophysiology in Europe: results of the European Heart Rhythm 10 Association Survey

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25 Despite the advent of non-fluoroscopic technologies, fluoroscopy remains the cornerstone of imaging in most interventional electrophysio-  
logical procedures, from diagnostic studies to ablation interventions and device implantation. The purpose of the European Heart Rhythm As-  
sociation survey was to provide an insight into regulatory policies and physicians' clinical practice when using fluoroscopy during ablation  
procedures and device implantation. The survey has shown that only 50% of the participating centres worked with low frame rates (3–6 frames  
per second) and that the left anterior oblique projection, with higher radiation exposure for the physician, is used for nearly every ablation  
30 target. Although three-dimensional imaging systems may reduce the radiation exposure, most centres never used these systems for standard  
ablation procedures and a trend is that non-fluoroscopy technologies are even less frequently used than in 2012, when the use of robotic sys-  
tems was still rare. Even less costly equipment such as lead gloves, lead glass cabins, or radiation absorbing pads are still not routinely used.

## Keywords

Radiation • Exposure • Fluoroscopy • X-ray • Electrophysiology • Ablation • Implantable cardioverter-  
defibrillator • 3D systems • EHRA survey • EP wire

## 40 Introduction

For every electrophysiological (EP) study or device implantation, the use of X-rays is still crucial. Nevertheless, as radiation exposure may be harmful for physicians and patients, a number of efforts to reduce fluoroscopy time have been made. In 2012, the results of the EP wire survey of the use of radiation in Europe were published.<sup>1</sup> The survey has shown that the EP Research Network participating centres used lead gloves, radiation absorbing pads, and lead glass cabins infrequently, but increasingly used three-dimensional (3D) mapping systems to decrease X-ray radiation hazards. Digital fluoroscopy with decreased frame rate has not been yet adopted by approximately one-third of the centres. With the introduction of more advanced mapping systems, radiation may be minimized. The purpose of this European Heart Rhythm Association (EHRA) survey was to assess the current routines and compared it with the former routines of

fluoroscopy use among members of the EHRA EP Research Network.

## Methods and results

### Participating centres

This survey was based on the questionnaire sent via the Internet to the EHRA EP Research Network centres. Overall, 35 centres responded, 28 (80%) of which were university hospitals, 3 (9%) private hospitals, and 4 (11%) were other type hospitals. The responding centres were mostly characterized by middle and high volume procedure numbers for implantable cardioverter-defibrillators (ICDs): 40% of centres performed 200 or more ICD implantations and 49% performed 50–199 procedures. The responding centres were mixed for EP procedure numbers: 49% performed more than 200

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115 left atrial catheter ablations, 17% performed 50–99 procedures but  
34% did less than 49 procedures in the previous calendar year.

120 **Policies and practices regarding X-ray exposure**

125 In order to reduce X-ray exposure, 50% of the centres used lower  
fluoroscopy pulse rates such as 3 or 6 frames per second (fps) (Fig-  
130 **Q5** ure 1), but there were still those (25%) who routinely used 12  
frames or higher. During the implant procedures, positioning of  
135 the leads was more often documented by storing the last sequence  
of fluoroscopy instead of using cines (45 vs. 29%); this was also the  
case for the coronary sinus lead in cardiac resynchronization ther-  
140 apy (CRT) device implantations (45 vs. 32%).

135 It was a common practice among the participating centres to  
record images with either storage of the last sequence of fluoros-  
copy or cine during device implantation procedures, but this prac-  
tice was less common during EP procedures: the centres did not  
document any images for ablation of atrioventricular nodal re-  
entrant tachycardia (AVNRT) (64%), typical flutter (74%), Wolff-  
140 Parkinson-White syndrome (45%), ventricular tachycardia (46%),  
the transseptal puncture site (61%), and pulmonary vein isolation  
(PVI) procedures (51%). If the successful ablation site was documen-  
ted, in most centres it was done by storage of the last fluoroscopic  
sequence instead of using cine. Even during PVI procedures, the con-  
145 trast injection was neither documented at the beginning (58%) nor  
at the end (100%). If it was documented, it was usually done by  
storage of the last fluoroscopic sequence in 23% and by cine in  
19% of the centres.

145 *Figure 2* illustrates the fluoroscopy planes routinely used for dif-  
ferent ablation targets. Interestingly, in most cases the left anterior  
oblique (LAO) projection, with a higher radiation exposure for the  
physician, is used for nearly every ablation target. For device implan-  
150 tations, the majority of centres used fixed installed single plane units,  
with 55% of the centres always using it and 24% sometimes, fol-  
lowed by mobile units (always: 25%, sometimes: 21%) and fixed

installed biplane units used sometimes by 31% of the centres.  
One centre used a rotational X-ray unit.

175 For EP and ablation procedures, a fixed installed single plane unit  
was most commonly used (always: 59%, sometimes: 24%), followed  
by a fixed installed biplane unit (always: 19%, sometimes: 27%). The  
180 use of a mobile unit was less common, with only 22% centres re-  
porting using it always 22% and 4% sometimes as was the use of a  
rotational X-ray unit (always: 7%, sometimes: 26%). Five centres  
(16%) sometimes worked with the robotic navigation systems:  
185 Hansen Medical (three centres) and Stereotaxis (two centres).  
One centre reported using MediGuide system (St Jude Medical).

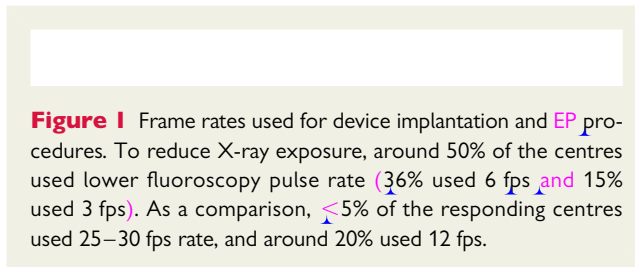
185 The use of other safety measures and techniques has also been  
evaluated (*Figure 3*). Other techniques used to minimize radiation  
exposure included 3D mapping systems for routine cases (61%),  
190 integration of fluoroscopy images in 3D mapping systems (UniVu,  
Biosense Webster; 40%), or the use of robotic systems (Hansen,  
14%; MediGuide, 4%).

190 Although a 3D system may reduce the radiation exposure, most  
centres (65%) never used and only 8% always used it for typical  
AVNRT interventions. For typical flutter-related procedures, 48%  
never used a 3D system and 26% always used it, and for ablation  
of atrial tachycardia, 14% never used a 3D system, whereas 73%  
195 always used it. One reason for not using a 3D system may be that  
in almost half the centres, there is no reimbursement for this  
technique which is associated with significant costs.

195 Specific clinical situations when EP studies or device implanta-  
tions were performed without fluoroscopy and only with a 3D map-  
ping system, included paediatric patients (127 cases performed in 24  
200 (77%) centres) and pregnant women (20 cases performed in 29  
(82%) centres). Twenty-six (73%) centres reported using the 3D  
mapping system in any patient when the operator felt confident  
(the total number of cases 270).

205 **Radiation dose**

Only limited data on the X-ray dose have been collected because of  
the difficulty dealing with different measurement units reported by



155 **Figure 1** Frame rates used for device implantation and EP pro-  
cedures. To reduce X-ray exposure, around 50% of the centres  
used lower fluoroscopy pulse rate (36% used 6 fps and 15%  
used 3 fps). As a comparison, 5% of the responding centres  
160 used 25–30 fps rate, and around 20% used 12 fps.

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**Figure 2** Routinely used planes for different ablation targets. The majority of the responding centres routinely used the LAO view in every ablation target, the X-ray exposure diminishing RAO or AP views are used in only around 50% of procedures. AP, antero-posterior; AV, atrioventricular; LAO, left anterior oblique; LIPV, left superior pulmonary vein; LSPV, left superior pulmonary vein; RAO, right anterior oblique; RIPV, right inferior pulmonary vein; RSPV, right superior pulmonary vein; VT, ventricular tachycardia; WPW, Wolff-Parkinson-White.

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the responding centres. Documentations made in  $\text{mGy m}^2$  revealed that the mean radiation dose for supraventricular tachycardia procedures was  $3.7 \text{ mGy m}^2$  (9 min), for PVI  $6.1 \text{ mGy m}^2$  (16 min), for pacemaker implantation  $1.5 \text{ mGy m}^2$  (4 min), and for CRT device implantations  $21.6 \text{ mGy m}^2$  (16 min).

In most centres, the radiation doses are measured for each physician individually; only one centre reported that individual doses are not measured. For routine monitoring, operators use dosimeters placed over the lead apron (52% of the respondents), beneath the apron (65%), and finger dosimeters (26%). Regarding the monthly and yearly staff X-ray exposure limits, 26% stated that did not know about these limits, 9% indicated a maximum yearly dose of 50 mSv, 52% reported a maximum yearly dose of 20 mSv, and 9% reported a 3 mSv monthly dose. Yearly health check-ups are performed in 60% of the responding centres. If the individual monthly or yearly X-ray burden exceeds the limits, more comprehensive personal radiation measurements were undertaken (41% of responders), blood laboratory tests were performed (22%), or a person was allowed to perform a specific number of procedures (73%).

The absolute majority of the respondents has observed no possible health damage as a result of X-ray radiation. No one mentioned radiation dermatitis in colleagues or themselves, but 13% mentioned radiation dermatitis in their patients. One responder indicated that malignancy in EP colleagues could be possibly attributable to occupational X-ray radiation.

Working with X-ray technicians during the procedure is still not very common in Europe (31% of the responding centres), but 40% of the physicians were required to obtain a certification before using X-rays by either participating in an educational course (41%), an examination (6%), or both (32%). Only 22% of the centres did not have a requirement for a course or an examination on the radiation safety.

## Discussion

The number and complexity of EP procedures and cardiac rhythm device implantation are steadily increasing which may result in higher radiation exposure for both physicians and patients. The results of this survey have demonstrated that only 50% of the selected European centres work with lower frame rates, despite well-demonstrated effectiveness.<sup>2</sup> This is nearly the same figure as the EP wire results in 2012. In the responding centres, it was quite common (in up to 75% in EP and up to 45% in device implantations) not to store images and if they indeed were documented, it was done by storage of the last fluoroscopic sequence instead of cines in most centres. In EP procedures the LAO projection, with higher radiation exposure for the physician, was most frequently used for nearly every ablation target.

Three-dimensional mapping systems were reported to be used less often to reduce X-ray dosage in this EP Wire compared with the results in 2012 (61 vs. 73%), but the integration of fluoroscopy images in the 3D mapping system (UniVu, Biosense Webster) seems to be a quite frequently used tool (40%), whereas the use of robotic systems did not increase in the last 2 years (still under 20%). In line with these observations, in over 400 procedures, the responding centres performed zero fluoroscopy procedures with the help of 3D imaging systems only (both EP and device implantations). A summary of imaging techniques available has been reported in recently published proceedings of the first joint EHRA Policy Conference on the use of imaging for EP and devices.<sup>3</sup>

The results of this survey highlight the fact that the European centres have adopted the standard use of individual lead aprons and shields and beam collimation over the last years emphasizing their routine establishment in clinical practice, but other measures such as radiation absorbing sterile drapes or gloves are still underused.

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**Figure 3** Safety measures and techniques used to decrease X-ray radiation during electrophysiology procedures.

Nearly 80% of the physicians were required to obtain a certification before using X-rays by either undertaking the course, exams, or both. However, these courses may be too general and not timely enough to encourage electrophysiologists to revise their X-ray policy to achieve the target reduction in radiation exposure by a factor 10–100.<sup>4</sup>

## Conclusion

This EP Wire survey on occupational X-ray hazards in EP reflects a static situation in the last 2 years, except for some technical achievements such as the integration of fluoroscopy images in the 3D mapping systems. Although less costly tools are available including decreased frame rates, lead gloves, radiation absorbing pads, and lead glass cabins, these are still infrequently used. In line with these observations, the LAO view is favoured over the postero-anterior or right anterior oblique views that are associated with less radiation exposure. Further efforts have to be made to encourage electrophysiologists to rethink and revise their X-ray policy to reduce X-ray exposure in EP procedures.

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## References

- Marinskis G, Bongiorni MG, Dages N, Lewalter T, Pison L, Blomstrom-Lundqvist C et al. X-ray exposure hazards for physicians performing ablation procedures and device implantation: results of the European Heart Rhythm Association survey. *Europace* 2013;**15**:444–6.
- Rogers DPS, England F, Lozhkin K, Lowe MD, Lambiase PD, Chow AWC. Improving safety in the electrophysiology laboratory using a simple radiation dose reduction strategy: a study of 1007 radiofrequency ablation procedures. *Heart* 2011;**97**: 366–70.
- Blomström-Lundqvist C, Auricchio A, Brugada J, Boriani G, Bremerich J, Cabrera JA et al. The use of imaging for electrophysiological and devices procedures: a report from the first European Heart Rhythm Association Policy Conference, jointly organized with the European Association of Cardiovascular Imaging (EACVI), the Council of Cardiovascular Imaging and the European Society of Cardiac Radiology. *Europace* 2013;**15**:927–36.
- 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. *Europace* 2014;**16**:946–64.