REFERENCE LEVELS AT EUROPEAN LEVEL FOR CARDIAC INTERVENTIONAL PROCEDURES

R. Padovani1,*, E. Vano2, A. Trianni1, C. Bokou3, H. Bosmans4, D. Bor5, J. Jankowski6, P. Torbica7, K. Kepler8, A. Dowling9, C. Milu10, V. Tsapaki11, D. Salat12, J. Vassileva13 and K. Faulkner14

1Medical Physics Department, Udine Hospital, Italy
2Medial Physics Department, S. Carlos University Hospital, Madrid, Spain
3Luxembourg’s Hospital Association, Luxembourg
4Department of Radiology, Gasthuisberg University Hospital, Leuven Belgium
5Department of Engineering Physics, Ankara University, Turkey
6Radiation Protection Department, Nofer Institute of Occupational Medicine, Lodz, Poland
7Department of Radiology, Innsbruck University Hospital, Austria
8Tartu University, Tartu, Estonia
9Medical Physics Department, St. James’s Hospital, Dublin, Ireland
10Institute of Hygiene and Public Health, Bucarest, Romania
11Medical Physics Department, Athens General Hospital, Athens, Greece
12QA Department, Faculty of Public Health, Trencin, Slovakia
13National Centre of Radiobiology and Radiation Protection, Sofia, Bulgaria
14QARC, Wallsend, Newcastle, UK

In interventional cardiology, a wide variation in patient dose for the same type of procedure has been recognised by different studies. Variation is almost due to procedure complexity, equipment performance, procedure protocol and operator skill. The SENTINEL consortium has performed a survey in nine European centres collecting information on near 2000 procedures, and a new set of reference levels (RLs) for coronary angiography and angioplasty and diagnostic electrophysiology has been assessed for air kerma-area product: 45, 85 and 35 Gy cm², effective dose: 8, 15 and 6 mSv, cumulative dose at interventional reference point: 650 and 1500 mGy, fluoroscopy time: 6.5, 15.5 and 21 min and cine frames: 700 and 1000 images, respectively. Because equipment performance and set-up are the factors contributing to patient dose variability, entrance surface air kerma for fluoroscopy, 13 mGy min⁻¹, and image acquisition, 0.10 mGy per frame, have also been proposed in the set of RLs.

INTRODUCTION

Interventional cardiology is a medical specialty widely known to potentially deliver high radiation dose to patients, who may receive, in some complex cases, high organ doses and skin doses over the threshold for deterministic effects.

The radiation dose depends on a number of factors, including patient size, equipment, technique and type of examination. Large variation in patient dose, for the same type of X-ray examination, has been demonstrated in several studies(1–5). These variations are almost due to different complexities of the procedures, equipment performance, procedure protocols and patient body size.

By investigating the patient dose, variations can be acknowledged, causes can be found and necessary adjustments can be implemented.

Reference levels (RLs) provide a framework to reduce this variability and assist in the optimisation process(6–8). For this reason, monitoring patient exposure in prolonged interventional procedures and comparison with RLs are mandatory tasks in every quality assurance programme.
interventional reference point (IRP), were provided. The accuracy of dose values provided has been submitted to a dosimetry intercomparison by the Lodz (Poland) partner.

RESULTS AND DISCUSSION

Coronary angiography procedures

Examined dose or dose analogue data exhibit a large variability. In Figures 1 and 2, mean and median values of FT and KAP, respectively, are reported for CA procedures.

The examinations have been pooled, and the frequency distribution of FT, number of frames and KAP have been derived together with the associated RLs. RLs have been assessed as the rounded values of the 75th percentile of distributions.

Figures 3 and 4 report the histograms of FT and KAP values, respectively, for all CA procedures evaluated in this study.

PTCA procedures

In Figures 5 and 6, histograms of FT and KAP, respectively, for PTCA procedures are reported.

Electrophysiology procedures

Frequency distribution histograms approximate a log-normal shape in all cases. This result represents the effects of differences between patient sizes and...
procedure protocols, as well as technical differences between equipment.

Reasons arise from a variety of RFCAs performed to treat different arrhythmias: atrial fibrillation, atrial flutter, nodal tachycardia, ventricular tachycardia and Wolff-Parkinson-White syndrome (WPW). Important differences in procedure protocols provide different mean FT and KAP values.

In Figure 7, the frequency distribution of FT for RFCA procedures is reported and it is possible to recognise the distribution does not have a log-normal shape.

Figures 8 and 9 report the data from an electrophysiology laboratory (Udine Hospital, Italy), where the information on type of RFCA have been collected. It is possible to recognise that the treatment for atrial fibrillation is the procedure that requires the highest FT (median value of 45 min) and, consequently, the highest KAP (median value of 35 Gy cm²) values.

The data of electrophysiology collected in the Udine Hospital imply the impossibility to pool all RFCA data together.

In contrast, the data available for each single procedure are insufficient to treat them separately. Consequently, from this survey, it is not possible to assess RLs (DRLs) for RFCA procedures.
Table 2. SENTINEL RLs for interventional cardiac procedures.

<table>
<thead>
<tr>
<th>Dose or dose analogue</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CA</td>
</tr>
<tr>
<td>KAP (Gy cm²)</td>
<td>45</td>
</tr>
<tr>
<td>Effective dose (mSv)</td>
<td>8</td>
</tr>
<tr>
<td>CD at IRP (mGy)</td>
<td>650</td>
</tr>
<tr>
<td>FT (min)</td>
<td>6.5</td>
</tr>
<tr>
<td>Number of cine images</td>
<td>700</td>
</tr>
<tr>
<td>Entrance surface air</td>
<td>Fluoro low: 13 mGy min⁻¹</td>
</tr>
<tr>
<td>kerma rate</td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION

The SENTINEL survey performed on interventional cardiology in a sample of European centres demonstrates the presence of a large variability in the entrance surface air kerma rates for both fluoroscopy and image acquisition modes. For the first time, RLs for these quantities are proposed to be used in the process of optimisation of patient exposure.

The SENTINEL RLs assessed also include the effective dose, calculated from the KAP reference value, and the CD at the IRP, quantity today displayed in the interventional room by the new equipment.

FUNDING

The SENTINEL project is supported by the European Commission, Euratom Research and Training Programme on Nuclear Energy, contract no. 012909.

REFERENCES


Reference levels

In Table 2, RLs, assessed as the rounded value of the 75th percentile of distributions, are reported for FT, KAP, CD at IRP, effective dose (defined as $E = 0.18 \times KAP$) and number of cine images.

Because equipment performance and set-up by the maintenance service are also important factors contributing to patient dose variability, entrance surface air kerma for fluoroscopy and image acquisition, measured at the entrance of a 20 cm PMMA phantom, are also introduced in the set of proposed RLs.

The RLs proposed for coronary angiography and angioplasty are lower when compared with those assessed in 2004 by the DIMOND group (CA:KAP = 57; PTCA:KAP = 94 Gy cm²)(7). The main difference derives from the lower number of cine images that had influenced the KAP.

Regarding the introduction of the CD at IRP in the set of RLs, it is necessary to better evaluate the impact of this quantity in the optimisation process of patient exposure.