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Editorial

Optimizing radiation exposure in interventional cardiology: are current doses appropriate?

¿Son adecuadas las dosis de radiación que utilizamos en los procedimientos intervencionistas?

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Are the radiation doses we use in interventional procedures appropriate? Cardiologists should be able to answer this question, which is particularly important in pediatric patients. However, the answer matters not only to patients but also to the health professionals involved in these procedures. The occupational radiation doses received by health staff are associated with the doses received by patients, and "optimization" (keeping radiation doses to the minimum needed to achieve the clinical objective of the procedures involved) should be managed comprehensively for patients and professionals alike.[1]

The International Commission on Radiological Protection (ICRP) recommends using "diagnostic reference levels" (DRLs) to help in the optimization of imaging modalities with ionizing radiation (including interventional procedures).[2]

DRLs are indicative of "good clinical practice". It is recommended that they be established for specific clinical indications and can be estimated for the local, national, or regional level by using the third quartile of the distribution of the median values of the dose indicators for patients from various centers representative of these clinical practices.[2]

The term "achievable dose value" has been proposed in the United States for the 50th percentile instead of the third quartile. Although the ICRP has stated that the median could be used as an additional step in optimization, the recommendation of using the third quartile recommendation to estimate DRLs still stands.[2]

For interventional procedures, the most widely used radiological measure is the kerma-area product (KAP), which is numerically equivalent to the dose-area product (DAP), and serves as one of the main indicators of the radiation doses received by patients. Secondary indicators that can also be used are the kerma at the patient entrance reference point (15 cm below the isocenter), fluoroscopy time, and the number of cine images acquired. These latter 2 indicators are becoming less relevant because doses depend on different image acquisition modes.

The ICRP recommends taking into consideration the complexity of interventional procedures, since it can increase DRLs significantly. Because complexity can vary widely for a single procedure, carried out for the same or similar clinical indications, it is important to assess its impact on the doses delivered to patients.[3,4]

The ICRP recommendations have been included in the European regulations (Directive 59/2013 EURATOM)[5] and the corresponding practical guidelines of the European Union.[6,7] For pediatric procedures, it is suggested that DRLs be estimated based on patient age and weight categories.[2]

The radiation doses received by pediatric patients vary widely depending on their size and weight. Although variations are inevitable, we should try to avoid those stemming from inappropriate use of imaging modalities (different fluoroscopy or cine modes) or protocols. DRLs help optimize radiation protection.

Different fluoroscopy and cine modes with varying dose rates (and image quality) can be used, substantially impacting the radiation doses received by patients. Factors that play a key role in delivered radiation doses are collimation, C-arm x-ray machine angles, fluoroscopy sequence recording to save cine sequences, and rotational acquisitions.

Ways to significantly reduce the radiation doses received by patients and health professionals are knowing the quality control results of x-ray machines (to understand dose differences between cine and fluoroscopy acquisitions) and fostering collaboration between hospital radiologists and cardiologists, along with continuous medical education programs on radiation safety.

All these variables associated with different operating modes can substantially change the doses delivered to patients and the quality of diagnostic information. Therefore, cardiologists' knowledge and experience of their imaging equipment are crucial. In general, state-of-the-art machines reduce radiation doses while maintaining similar or improved diagnostic information. Quantifying all these

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factors and deciding whether corrective actions are needed involves comparing radiation doses for specific procedures with the DRLs.

The Royal Decree that transposes part of the European Directive to the Spanish legislation[8] demonstrates the implementation and regular review of DRLs. If these DRLs are consistently and significantly exceeded, or if image quality deteriorates repeatedly, the corresponding local reviews should be undertaken and appropriate corrective measures should be implemented without delay.

Some automated dose management systems allow real-time reception and processing of the radiation doses received by patients and operators. These systems can create alerts for safer interventional practices.[9,10]

Several studies have been published on DRLs in interventional cardiology for adult patients (DOCCACI program) in Spain[11,12] with collaboration from the Spanish Society of Cardiology.

No nationwide results have been published on the doses received by pediatric patients in interventional cardiology until now. However, Rueda Núñez et al.[13] recently presented the results of the Radcong-21 Registry conducted by the Cardiac Catheterization Working Group of the Spanish Society of Pediatric Cardiology and Congenital Heart Disease (GTH-SECPCC) on the overall values from a sample of 1090 procedures across 10 different hospitals. This registry represents a significant initiative that could encourage other centers to compare their values with dose indicators obtained from a representative sample of multiple Spanish hospitals in patients with congenital heart disease treated with cardiac catheterization and categorized by type of procedure and estimated radiation risk (ERR).

The study authors used medians, although DRL values refer to the third quartile of the distribution of the median values in the different centers involved. Specific DAP/kg values are provided for certain specific procedures to treat prevalent conditions such as aortic coarctations, atrial septal defects, ductus arteriosus occlusions, aortic and pulmonary valvuloplasties and pulmonary valve implantations following the methodology proposed by Quinn et al.[14] in the United States.

DAP/kg/fluoroscopy is a parameter that can be confusing when comparing radiation doses. This is because the total DAP includes contributions from fluoroscopic imaging—corresponding to different fluoroscopy modes with very different dose values—and cine acquisitions.

To facilitate comparisons and potential optimization efforts, the authors could provide dose indicator values (DAP/kg) tailored to a wider range of procedure types in future updates of the results. They could also use the third quartiles of the distribution of the median values for each center for the weight categories recommended by the ICRP and European guidelines.[2,6,7]

We could speculate whether it would be better to perform a global analysis across groups of different procedures or an analysis specifically designed for procedures with specific clinical indications. Quinn et al.[14] choose the former, while managing the DAP/kg values as the primary dose parameter. However, a global approach does not allow analysis of specific procedures requiring corrective measures when the doses delivered to some patients may be very high. These doses exceeding the "good clinical practice" threshold can be used in certain procedures, but not in others, within the 3 REC (Radiation Exposure Category) groups proposed by Quinn et al.[14] in their methodology. The advantage of using DRLs per weight group is that these DLRs are estimated for specific clinical indications, thus enabling easy comparisons with the dose indicators used in different hospitals for these procedures.

The global KAP/kg values for groups of different procedures may be balanced if there are procedures using higher radiation doses than necessary (due to excessive cine acquisitions, high-dose fluoroscopy modes, lack of collimation, etc) and other procedures requiring standard doses. This could indicate overall improvement (fewer doses in procedural groups), but does not necessarily indicate improvement in all types of procedures.

The effort made by the GTH-SECPCC to obtain and process PDA/kg values represents a significant advancement that could be further expanded in the future. This could involve establishing initial DRLs (KAP values) in Spain, based on weight and age groups, following the recommendations of the European guidelines and ICRP.

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CONFLICTS OF INTEREST

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