Activities of EURADOS Working Group 12 in establishing DRLs for Interventional Radiology, Cardiology & Cone Beam CT

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Background/introduction

The European Radiation Dosimetry Group (EURADOS) is a self-sustainable network of more than 70 European institutions and 560 scientists. The aim of the network is to promote research and development and European cooperation in the field of dosimetry of ionizing radiation. The main scientific work is done in working groups, which promote technical developments and their implementation in routine work, and contribute to harmonization within Europe and conformance with international practices.

Working group 12 (WG12) Dosimetry in medical imaging of EURADOS addresses various aspects of dosimetry in medical imaging. The work of WG12 is particularly focused on harmonization, evaluation and development of dosimetry methods, intercomparisons, literature reviews and measurement campaigns to assess occupational and patient dose. In line with most recent developments in radiation protection in medicine, a lot of effort has been made in the area of patient dosimetry in medical imaging, in particular for interventional radiology and cardiology (IR and IC).

Following vision 4 of EURADOS’s Strategic Research Agenda (SRA): "Towards integrated personalized dosimetry in medical applications", part of WG12 work is currently focusing on the development and evaluation of dosimetric bases for organ dose and risk estimates in different imaging modalities, in particular in interventional radiology (IR) and interventional cardiology (IC) and in cone beam CT examinations (CBCT). The establishment and application of Dose Reference Levels (DRLs) have a key role in optimization of radiation protection. DRLs are particularly important for IR and IC patients who may receive radiation doses that are high enough to increase the incidence of radiation induced cancer. In addition, exposure of the skin and the heart vessels may be high enough during some IR and IC procedures to cause erythema and cardiovascular tissue reactions respectively. Therefore, alert levels are also a useful radiation protection tool.

Variations in dose levels between different hospitals and countries are expected to be large and there is a general need to analyze how locally (or how globally) reference levels can and should be set. To draw any conclusions, reliable data covering the widest range of practices are needed.
Description of activity and work performed

In the framework of EURADOS WG12, European consortium has been established with the aim to analyze patient exposure data and to propose new European DRLs for selected IR/IC procedures. Concerning IC, the data was collected from 13 EU countries (37 clinics and nearly 50 interventional rooms) for the following procedures: coronary angiography (CA), percutaneous coronary intervention (PCI), pacemaker implantation (PI), electrophysiological procedures (EF) and transcatheter aortic valve implantations (TAVI). This work is summarized in a publication (1). Overall, dose data was collected from a total of 14,922 interventional cardiology procedures. Based on these data, the following European DRLs are suggested: for CA 35 Gy cm\(^{-2}\), for PCI, 85 Gy cm\(^{-2}\) for TAVI 130 Gy cm\(^{-2}\) and, 12 Gy cm\(^{-2}\) for electrophysiological procedures and pacemaker implantations. Pacemaker implementations were further divided into single-chamber (2.5 Gy cm\(^{-2}\)) and dual chamber (3.5 Gy cm\(^{-2}\)) procedures and implantations of cardiac resynchronization therapy pacemaker (18 Gy cm\(^{-2}\)). The study shows that relatively new techniques such as TAVI and PCI for the and treatment of chronic total occlusion (CTO) often produce relatively high doses, and thus emphasizes the need for use of an optimization tool such as DRL to assist in reducing patient exposure.

The WG12 group also worked on the feasibility of setting-up generic, hospital-independent dose alert levels (2). The following high dose interventional procedures were studied in 9 European countries: transarterial chemoembolization (TACE) of the liver, neuro-embolization (NE) and percutaneous coronary intervention (PCI). In order to determine Maximum Skin Dose (MSD), Gafchromic® films and thermoluminescent dosimeters (TLD) were used to determine a correlation of the online dose indicators (fluoroscopy time, kerma- or dose-area product (KAP or DAP) and cumulative air kerma at interventional reference point (Kair)) with MSD. The results were evaluated and used to establish the alert levels corresponding to a MSD of 2 Gy and 5 Gy. The example of alert levels corresponding to MSD = 5 Gy for PCI, TACE and NE in different countries are given in Figures 1-3.

Additionally, the WG12 group undertook a survey aimed at establishing European DRL values for common dental Cone Beam CT (CBCT) examinations. The review showed that although limited information was available for patient studies, numerous experimental studies have been undertaken using phantoms of various types in conjunction with a range of radiation detectors. It is evident from the published literature that the most appropriate dose metric for dental CBCT imaging has yet to be agreed upon. While many studies have estimated effective doses, there is a noticeable lack of published data on the existence of DRLs at the local and national level for CBCT examinations in dental radiology. Before establishing European DRLs, the following challenges have
to be addressed: lack of optimisation performed on these systems, the necessity of more complementary training to educate users of dental CBCT X-ray and the need for the medical physics/engineering professions to become more closely involved in the management of dental CBCT imaging equipment.
Fig. 1: The comparison of alert levels corresponding to MSD = 5 Gy for PCI given as DAP in different countries. Error bars correspond to coverage factor $k = 1$

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Fig. 2: The comparison of alert levels corresponding to MSD = 5 Gy for TACE given as DAP in different countries. Error bars correspond to coverage factor $k = 1$

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Fig. 3: The comparison of alert levels corresponding to MSD = 5 Gy for NE given as DAP in different countries. Error bars correspond to coverage factor k = 1

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Conclusion and recommendations

Part of the EURADOS WG12 work is focusing on patient dosimetry in medical imaging with the aim to improve dosimetry methods, to increase awareness amongst the medical professionals and to foster the implementation of the optimization principle by establishing DRLs for specific examinations.

WG12 recently collected patient exposure data from 13 countries (37 clinics and nearly 50 interventional rooms) and for 10 different procedures to establish European DRLs for IR and IC procedures. The study shows (1) that for the new procedures it is difficult to set local reference levels so in these cases generic DRL values can be applied.

The results of WG12 indicated that generic, hospital-independent alert levels are feasible in some interventional procedures (like chemoembolization of the liver) but should be used cautiously, only as the first approximation; hospital-specific alert levels are preferred as the final approach and should be set to reflect the clinic’s specific working procedures.

When the procedures are well established local DRLs should be set since variations between countries or even within the country can be large.

For dental CBCT examinations, and given the identified challenges, future work involves the drafting of detailed guidelines outlining how DRLs should be established.

Even though work is still in progress, it has been clear demonstrated several times, that such working groups from different European partners allow for a better understanding of radiation protection throughout European hospitals.
Personal/organisational information

This work was carried out in the frame of the EURADOS Working Group 12 - Dosimetry in Medical Imaging