RADIATION PROTECTION OF MEDICAL STAFF: A COORDINATED ACTION BY EURADOS ON EXTREMITY DOSIMETRY AND THE USE OF ACTIVE PERSONAL DOSEMETERS (CONRAD)

Background

Monitoring of workers constitutes an integral part of any radiological protection program. However, unresolved issues in radiation protection of medical staff still remain. Research and establishment of guidelines are necessary on a variety of issues such as extremity dosimetry (fingers, eye lenses, etc), the use of double dosimetry above and below lead aprons, or the use of electronic personal dosimeters in interventional procedures. Medical practices are also evolving fast, and new techniques with ionising radiation emerge very regularly, thus implying the need of radiation protection measures for medical staff, and the implementation of new monitoring programs. In some medical applications of radiation there is an increased risk of high local exposures because of direct handling of sources or the use of beta-emitters. However, despite the large number of workers that are exposed in the medical field worldwide, only few measurements of extremity doses have been reported in the literature.

Objectives

Some activities of EURADOS Working Group 9 (WG9) were sponsored by the European Commission in the CONRAD project. This CONRAD project was aiming at the coordination of research on radiation protection at the workplace. Working group 9 has been involved in the coordination and promotion of European research in the field of ***Radiation Protection Dosimetry for Medical Staff***. One of the objectives of this working group was to formulate the state of the art and to identify areas in which improvements were needed.

For some of these medical applications the skin of the fingers is the limiting organ from the point of view of individual monitoring of external radiation. The wide variety of radiation field characteristics in a medical environment, and the difficulty of measuring a local dose that is representative for the maximum skin dose (usually with one single detector), makes it difficult to perform extremity dosimetry with an accuracy similar to whole-body dosimetry. Therefore a subgroup of WG9 dealt specifically with the use of extremity dosemeters in medical radiation fields.

Active personal dosimeters (APDs) are very efficient tools to monitor occupational doses in real time during exposure and provide selectable alarm levels to avoid high doses. Interventional radiology operators belong to a specific worker category, which would benefit from a real time, accurate assessment of their dose. Another subgroup dealt with the adequate dosimetry of scattered photons, using APDs. They must be able to respond to low-energy [10-100 keV] and pulsed radiation with relatively high instantaneous dose rates.

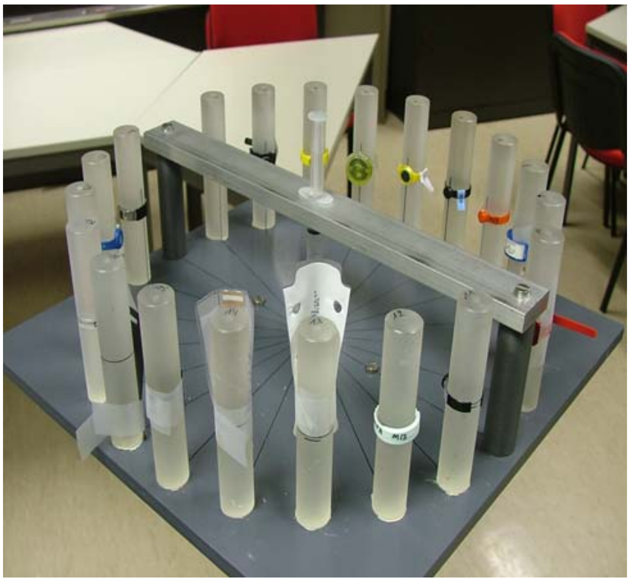
Principal results

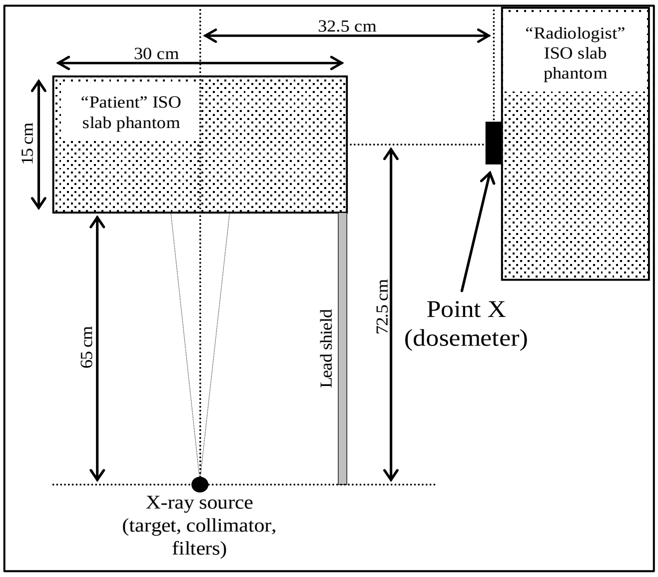
The first subgroup prepared an inventory of sites and situations presenting extremity dosimetry issues (conventional nuclear medicine, radiotherapy and PET (positron emission tomography), interventional radiology and cardiology, manual brachytherapy, together with a thorough literature review. For several countries, data has been collected on the number of extremity dosimeters used in the different fields, and on the magnitude of doses that are being measured. Moreover, early 2007, an intercomparison for ring dosimeters, coordinated by SCK•CEN, was organised between 24 European dosimetry services. The overall objective was to verify the performance of different extremity dosimeters in measuring the quantity $H_p(0.07)$ in photon and beta reference fields. The irradiation fields comprised: (1) ^{137}Cs gamma rays (irradiations at 0°, 180°), (2) fields simulating interventional radiology (IR) workplace conditions (generated using 70 kVp X-ray beams and a phantom), (3) some beta radiation fields from ^{90}Sr/90Y, ^{85}Kr, and ^{147}Pm sources (irradiations at 0°and 60°) and (4) two fields simulating workplace conditions typical of nuclear medicine departments: an unshielded syringe containing ^{99m}Tc (without shield) and ^{18}F (figure a). The following conclusions could be drawn after the first evaluation of the present intercomparison:

- There are services that use ^{137}Cs sources for calibration and still present a serious deviation from the conventional true value of Hp(0.07);
- The general overestimation in the IR fields could be explained by the energy response of LiF;
- The underestimated response of detectors to ^{18}F is due to the positron flux that significantly contributes to the dose from unshielded syringes;
- There is a clear correlation between filter and detector thickness and response to beta particles;
- Only a few dosimeters show good results for all radiation qualities, especially the ones with thin detectors and filters.

In March 2007, the second subgroup organised an intercomparison of five APD models deemed suitable for application in interventional radiology in France. Both pulsed and continuous X-ray beams were used. The reference value at point X (figure b) was based on measurements with a cavity ionisation chamber calibrated in the direct beam in terms of free-in-air kerma. The X-ray transport through the water-slab patient-phantom was calculated by IRSN, CEA and SCK•CEN using different codes: MCNP, MCNPX and PENELOPE 2006. The conversion coefficient was derived from the ratio, at point X, of calculated values of $H_p(10)$ and K_a. The latter was calculated in a 1 cm radius sphere filled with air and centred at point X, in the absence of the radiologist-phantom. $H_p(10)$ was calculated as the dose scored in a cell centred at point X, at depth 10 mm in a 30 cm × 30 cm × 15 cm phantom, representing the radiologist. The results of the intercomparison of the APDs were:

- four dosimeters out of five are sensitive to the single pulse radiation;
- the requirement of IEC standard in terms of energy response is not fulfilled for only one dosimeter (DIS 100);
- Except for model PM 1621A, a systematically larger response for the pulsed field than for the continuous one (13 % on average) is observed;
- The observed standard deviations ranged between 0.3 and 1.5 % for a single APD (repeated irradiations) and less than or equal to 5 % for two APDs of the same type (14 % was observed for one type).





(a) (b)

Pictures of the ring dosimeter intercomparison set-up for realistic nuclear medicine fields (a) and for the intercomparison of APDs for realistic fields in interventional radiology (b)

Future work

The activities on the extremity dosimetry and active personal dosimeters in medical fields will be continued and elaborated in detail in the new European FP7 project ORAMED: Optimisation of Radiation Protection of Medical Staff. This project will be coordinated by the SCK•CEN.

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Main references

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