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Effectiveness of staff radioprotective equipment during fluoroscopically-guided procedures: Results and recommendations from the MEDIRAD project

Purpose

Various types of radioprotective (RP) equipment exist to protect the staff during fluoroscopically-guided procedures; however, their performance can widely vary and is challenging to assess in clinical practice. To support evidence-based selection of RP equipment, the effectiveness of lead(-free) caps, lead-free aprons, lead(-free) drapes, masks and the Zero-Gravity suspended system was investigated.

Materials and Method

The effectiveness to reduce staff X-ray exposure was investigated by means of Monte Carlo (MC) simulations completed by clinical measurements on staff and phantoms.

Numerous irradiation configurations, including beam projections (at least five) and staff distance from the source (at least two), were modelled. Different equipment compositions and designs were considered where applicable.

The clinical measurements included from a few tens of procedures up to over 600, while phantom measurements included three common and/or concerning configurations.

Recommendations were derived from the study results, including feedback from relevant stakeholders.

Results

According to MC results, a lead(-free) cap reduced the brain dose by 35% on average. The mask could be more effective (65% average reduction for the best model) and also protect the eye (25%). However, the irradiation conditions had a strong influence as both equipment types could become nearly ineffective in specific configurations, particularly when closer to the X-ray field. Besides, some brain regions were left unprotected. Phantom measurements corroborated the results, although with lower effectiveness figures.

The lead(-free) drape over the patient could decrease the dose to the skin of the hands (from MC results: 62% and 30% to the left and right hands on average, respectively) if positioned directly above it. No noticeable effect was observed for other organs. Some clinical measurements, however, also showed considerable dose reduction (˜50%) to the eye lens which were not predicted by MC simulations or phantom measurements.

The effectiveness of lead and lead-free aprons to protect the organs in the chest region was comparable, according to the MC and clinical measurements.

The Zero-Gravity system offered the highest protection to the brain and eye lens according to MC, phantom and clinical results (at least 95%, 66% and 78% on average, respectively), and a protection level comparable to the lead apron for the organs normally covered.

Discussions and conclusions

All the equipment types showed potential for dose reduction. However, the effectiveness of the caps, the masks and the drapes strongly depends on the design, exposure conditions and staff position. In adverse exposure conditions, they can become ineffective.

Independent testing of RP equipment, with reference to typical and realistic conditions of use, would be of great help for the staff to select such equipment. Considering the expertise, time and material necessary for such testing, involving professional associations and RP equipment manufacturers, would be beneficial.

Recommendations were summarised into a concise document aimed at medical physicists and staff. It contains pros and cons of the tested equipment types as well as other commonly used ones.

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