Implications in medical imaging of the new ICRP thresholds for tissue reactions

E. Vano, D.L. Miller and L. Dauer

Abu Dhabi

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New ICRP thresholds for tissue reactions

- The ICRP Statement on Tissue Reactions issued by the Commission in April 2011 reviewed epidemiological evidence and suggested that there are some tissue reactions where threshold doses are or might be lower than those previously considered.
- For the lens of the eye, the threshold is now considered to be 0.5 Gy. The absorbed dose threshold for circulatory disease in the heart and brain may be as low as 0.5 Gy.
Implications in medical imaging

- These values may be reached in some patients (and staff) during interventional cardiology or neuroradiology procedures.
- The new thresholds should be considered during the justification process and in optimization strategies for clinical procedures, especially in patients likely to require repeated interventions.
Organ dose calculations in cardiac and neuro interventional procedures

In some of these procedures incident air dose may be several Gy
In interventional cardiology procedures, the heart dose can be estimated as approximately 20-25% of the cumulative entrance air kerma (CAK). 
CAK > 2.0-2.5 Gy implies a heart dose > 0.5 Gy
All cardiac procedures (SCUH 2010-2011)

10% > 2.5 Gy
17% > 2.0 Gy

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Therapeutic procedures only
CAK (mGy), SCUH Madrid

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16% > 2.5 Gy
27% > 2.0 Gy

Thus, 16-27% of procedures likely result in > 0.5 Gy to the heart (organ dose)
For some complex procedures, absorbed dose to the skin can be several Gy and heart doses can be much higher than 0.5 Gy.
The radiation dose delivered to the brain was estimated using MC software in 99 diagnostic and therapeutic neuroradiology procedures. A total of 9031 beam projections were processed.

For cerebral embolizations, average brain doses were 0.5 Gy. In 34% of cases brain doses were \( \geq 0.5 \text{ Gy} \).

A CAK of 1000 mGy implies approx. 270 mGy to the brain.

Estimation of brain doses should be part of the optimization process (and informed consent) especially for patients who have undergone several procedures and for paediatric patients.
Average absorbed doses to the brain when exposed to large uniform fields
(49 neuroembolizations; 21 (43%) > 500 mGy)
Brain doses in paediatric neuroradiology procedures

I. Thierry-Chef, S. L. Simon, C. E. Land and D. L. Miller
RADIATION RESEARCH 170, 553–565 (2008)

Impact of optimization (e.g. good collimation) but consider difficulties for organ dose estimations

Average absorbed doses to the brain when exposed to small, non-uniform fields. All < 0.5 Gy.
(49 neuroembolizations)
The new dose thresholds also affect occupational protection for operators and other staff.

Some operators do not protect their eyes or their brain adequately.

After several years of work without proper protection, absorbed doses to the lens and to the brain of staff can exceed 0.5 Gy.
Posterior subcapsular lens changes characteristic of ionizing radiation exposure were found in 50% of interventional cardiologists and 41% of nurses and technicians but only 10% of controls. Estimated cumulative eye doses ranged from 0.1–18.9 Sv. Most lens injuries result from several years of work without eye protection.
The new thresholds for tissue reactions, and the need for specific patient and staff dose evaluations and follow-up, must be considered in radiation protection programs and should be included in the education and training of professionals involved in fluoroscopy-guided procedures.
Existing Applicable ICRP Guidance

- **ICRP #85** - Avoidance of Radiation Injuries from Medical Interventional Procedures.
- **ICRP #105** - Radiological Protection in Medicine.
- **ICRP #113** - Education and Training in Radiological Protection for Diagnostic and Interventional Procedures.
- **ICRP #117** - Radiological Protection in Fluoroscopically Guided Procedures Outside the Imaging Department.
- **ICRP #120** - Radiological Protection in Cardiology.