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Relation between organ and whole body doses and local doses measured by ESR

for standard and realistic neutron and photon external overexposures

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Objective

Context: in the case of a radiological accident due to external exposure, the assessment of the organs and whole body dose received by the victim is fundamental information for therapeutic strategy.

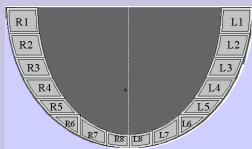
Means of our laboratory: two complementary dosimetric techniques: Monte Carlo calculations and ESR spectroscopy

Objectives: provide data relevant for a quick assessment of the dose distribution in case of accidental overexposure using dose ESR measurements performed on one or several points of the body for standard homogeneous exposures and exposures typical of accidental situations for monoenergetic photons and neutrons, and several sources (⁶⁰Co, ¹³⁷Cs, ¹⁹²Ir, ²⁵²Cf and AmBe).

Material and methods

Phantom:

- mathematical adult male phantom
- head with jaw and the 32 teeth:

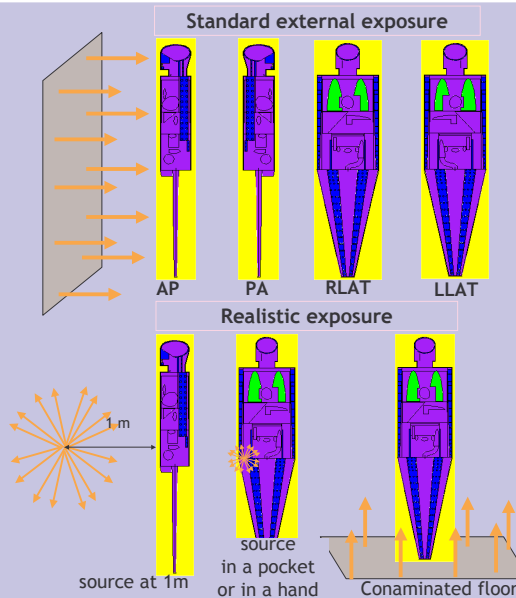


Specific points measurable by ESR:

- enamel + dentine
- 578 samples of bone in the skeleton
- sugars placed in the pockets

Method of calculation:

- MCNPX2.4 code



Radiation conditions:

- standard homogeneous monoenergetic parallel photon (10 keV to 10 MeV) and neutron (10⁻⁹ to 180 MeV) beams

- exposures typical of accidental situations (source at 1m, in a pocket, in a hand and contaminated floor) for several isotropic sources (⁶⁰Co, ¹³⁷Cs, ¹⁹²Ir, ²⁵²Cf and AmBe)

- Determination of ratio between organ and whole body dose and local dose :

$$\frac{D_{organ}}{D_{wholebody}} = \frac{D_{local}}{\sum m_i} \quad \text{with} \quad D_{wholebody} = \frac{\sum (D_i \cdot m_i)}{\sum m_i}$$

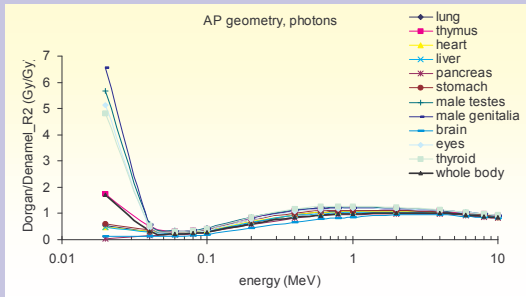
Results

Standard photon and neutron external exposures

Realistic photon and neutron external exposures

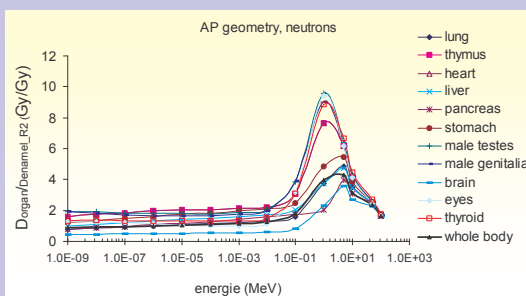
AP PA RLAT LLAT

Photons



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Neutrons



Dorgan / Ddenamel	source at 1m in front of phantom			
	¹⁹² Ir	¹³⁷ Cs	⁶⁰ Co	²⁵² Cf
	average photon energy (MeV)		average neutron energy (MeV)	
	0.38	0.66	1.25	2.1
lung	1.1	1.2	1.2	1.5
thymus	1.5	1.5	1.5	2.7
heart	1.2	1.3	1.3	1.9
liver	1.2	1.3	1.4	1.8
pancreas	1.1	1.2	1.2	1.2
stomach	1.5	1.5	1.5	2.4
male testes	2.0	2.0	2.0	4.3
male genitalia	1.9	2.0	1.9	4.0
brain	0.5	0.6	0.7	0.6
eyes	1.1	1.2	1.2	2.2
thyroid	0.8	1.0	1.0	1.0
whole body	1.1	1.2	1.2	1.6

Dorgan / Denamel	source at 1m in front of phantom			
	¹⁹² Ir	¹³⁷ Cs	⁶⁰ Co	²⁵² Cf
	average photon energy (MeV)		average neutron energy (MeV)	
	0.38	0.66	1.25	2.1
lung	1.1	1.2	1.3	5.9
thymus	1.4	1.6	1.5	10.6
heart	1.2	1.4	1.4	7.2
liver	1.2	1.4	1.4	7.1
pancreas	1.1	1.2	1.3	4.8
stomach	1.4	1.6	1.6	9.1
male testes	2.0	2.1	2.1	16.5
male genitalia	1.9	2.1	2.0	15.6
brain	0.5	0.6	0.7	2.2
eyes	1.1	1.2	1.2	8.6
thyroid	0.8	1.0	1.0	4.0
whole body	1.1	1.2	1.3	6.3

Conclusion

- The Monte Carlo calculations provided the relation between organ and whole body dose and the local dose in a point measured by ESR such tooth, a sample of bone or sugar in a pocket for standard and realistic neutron and photon external exposures.
- These data are useful for the individual dose assessment by the ESR dosimetry with biological (bone, enamel, dentine) and organic (sugars) materials.

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