Potential Improvements in Brain Dose Estimates for Internal Emitters

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Background: Element-specific biokinetic models are used to reconstruct doses to systemic tissues from internal emitters. Typically, a systemic model for a radionuclide explicitly depicts only its dominant repositories. Remaining tissues and fluids are aggregated into a pool called Other tissue in which the radionuclide is assumed to be uniformly distributed. In the systemic biokinetic models used in radiation protection, the brain usually is addressed as an implicit mass fraction of Other tissue rather than an explicitly depicted repository. Due to increasing interest in radiation effects on the brain, efforts are underway to improve brain dosimetry for internal radiation sources.

Methods: We assessed potential improvements in brain dosimetry for internal emitters by explicitly modeling brain kinetics rather than treating the brain as a mass fraction of Other tissue. We selected 10 elements for which brain kinetics can be modeled using published biokinetic data. Injection dose coefficients were calculated for a relatively long-lived radioisotope of each element using each of two versions of the ICRP's latest systemic biokinetic model for the element, the original version and a modified version differing only in the treatment of brain. If the ICRP model contained an explicit brain pool, the modified version depicted brain instead as a mass fraction of Other tissue. If the ICRP model included brain in Other tissue, the modified version included an explicit brain pool with kinetics based on best available brain-specific data.

Results: The result for a given radionuclide is expressed as a ratio A:B, where A and B are the dose coefficients based on the versions of the model with and without an explicit brain pool, respectively. The following ratios A:B were obtained for the 10 radionuclides addressed here: ^{241}Am, 0.13; ^{207}Bi, 0.57; ^{234}U, 0.81; ^{239}Pu, 0.96; ^{203}Hg (vapor), 1.4; ^{134}Cs, 1.5; ^{54}Mn, 1.7; ^{210}Po, 1.7; ^{226}Ra, 1.9; ^{210}Pb, 3.3. These ratios indicate that a dose estimate for brain based on a biokinetic model with brain implicitly contained in Other tissue may substantially underestimate or substantially overestimate a dose estimate that reflects best available brain-specific biokinetic data. Of course, the reliability of the latter estimate depends on the quality of the underlying biokinetic data.

Conclusions: Where feasible, the brain should be depicted explicitly in biokinetic models used in epidemiological studies addressing adverse effects of ionizing radiation.

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