Comparison of Two Methods to Estimate Skeletal Plutonium Concentration from Limited Sets of Bones

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Historically, two calculation methods have been used by the United States Transuranium and Uranium Registries (USTUR) to estimate the actinide skeletal concentration: (i) arithmetic average and (ii) mass-weighted average of concentrations measured in bone samples. Preliminary comparison of skeletal concentrations, estimated for 216 partial-body USTUR cases, using these two methods indicates a statistically significant difference ($p < 0.05$) with the bias of 15% between the estimates. The aim of this research is to determine: (1) which method of skeletal concentration estimate is more accurate for a given (collected) set of bones and (2) among the sets of bones most commonly collected for partial-body donations, which set provides more accurate estimate of the total skeletal concentration using each method. Nineteen whole-body cases with complete skeleton analyses were used to compare the estimates of the skeletal concentration based on different sets of bones with the concentration based on all measured bones from the right side of the skeleton. Out of 19 cases, ^{239}Pu was a primary radionuclide of exposure for 17, and ^{238}Pu for two cases. Five individuals were diagnosed with osteoporosis. Since osteoporosis significantly impacts plutonium distribution in the skeleton, 19 cases were divided in two study groups – osteoporotic (5) and non-osteoporotic (14). These cases were further sub-divided into 11 bone groups, based on a number of bones (2 to 8) and their frequency of collection at autopsies. These groups represent different balance of cortical- and trabecular-bone-rich bone samples. To compare the two methods, for each bone group, the arithmetic (C_a) and weighted (C_w) average plutonium concentrations were calculated and compared to the total skeleton concentrations (C_{sk}). Preliminary results indicated that, for all cases and all bone groups, both C_a and C_w predict C_{sk} within 10% of the best estimate and C_w yields slightly better estimate of the C_{sk} for non-osteoporotic cases; however, it has a higher uncertainty.

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