Estimation of Plutonium Concentration in Skeleton from Occupationally Exposed Individuals[†]

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Purpose: The skeleton is a major plutonium retention site in the human body. The estimation of the total plutonium activity in the skeleton is a challenging problem. For most tissue donors at the United States Transuranium and Uranium Registries, a limited number of bone samples is available. The total skeleton activity is calculated using plutonium activity concentration (C_{skel}) and skeleton weight. If limited number of was bone samples analyzed, C_{skel} could be estimated using multiple linear regression (MLR) of data from whole-body donors, where C_{skel} were estimated based on the analysis of the half of the skeleton. The caveat of MLR is that individual bone sample concentrations are correlated. Multicollinearity can be addressed by principal component regression (PCR).

Methods: A case with eight analyzed bone samples: vertebral arch, vertebral body, sternum body, patella, skull, femur middle shaft, femur distal end, rib, was used to demonstrate the application of PCR for prediction of C_{skel}. For each combination of these eight bone samples, PCR was performed using data from 14 non-osteoporotic whole-body donors, and C_{skel} was predicted for each combination. The predicted 95% confidence intervals were compared.

Results: The lowest relative width of confidence interval (6.5%) was achieved for the following four-bone combination: vertebral arch, vertebral body, patella, and skull. The widest confidence interval (90%) was observed for the combination of three bone samples: patella, skull, and femur middle shaft.

Conclusion: PCR was used to estimate C_{skel} for various bone sample combinations. Analysis revealed that a proper selection of bone samples significantly reduced the width of the 95% confidence interval of estimated C_{skel}.

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