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RADIOANALYSIS OF TISSUES FROM OCCUPATIONALLY EXPOSED WORKERS

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The US Transuranium Registry (USTR) instituted a program for whole-body donations in 1976 to improve the data on the distribution of transuranics within the entire skeleton and those tissues not available from a routine autopsy.[1] Whole-body donations are reserved for individuals with a systemic burden estimated to be 10% or greater of the maximum permissible body burden for a specific radionuclide. The USTR has obtained permission for 22 whole-body examinations. Two whole bodies have been submitted for radiochemical analyses. The first, an ^{241}Am exposure, has been described in an earlier report.[2] The second whole-body donor died at age 62 of congestive heart failure resulting from generalized atherosclerosis. The primary exposure was to ^{239}Pu in 1945. This individual, a chemist, was a member of the Manhattan Project and had been followed medically as a subject of Los Alamos health studies.[3] At the time of his death, it was estimated on the basis of urine bioassay that he had a body burden of 26.6 nCi of ^{239}Pu and 0.2 nCi of ^{238}Pu.

The internal organs were obtained at the time of autopsy. The remainder of the body was dissected at a later date in Richland, Washington, by the same team that dissected the first body. The bones of the right side of the skeleton were sectioned and identified for analyses in the same manner as the first skeleton so that direct comparisons of Am/Pu deposition ratios could be made. The bones and soft tissue (mainly skeletal muscle and skin) were frozen and shipped to Los Alamos

for analyses. All tissues are being analyzed for plutonium and americium by using the standard analytical procedures used by this Laboratory.[4]

The summarized ^{239}Pu results of the analyses are shown in Table IX. The ^{241}Am results are not complete at the time of this writing. The preliminary estimates of the total body deposition of ^{239}Pu is 6.5 nCi. Independent of these measurements and before the completion of the analysis, the computer code used to estimate the body burden of plutonium from urine assays was modified. The new code uses the Langham power function and a single 100-yr half-life exponential component, as proposed by ICRP Publication 19. It provides a better overall correlation between calculated and autopsy estimates of the body burden.* The revised computer code calculated a body burden of 7.3 nCi ^{239}Pu for this individual.

Table X lists the relative distribution of ^{241}Am and ^{239}Pu in the skeletons of the first two whole bodies analyzed. The distribution is remarkedly similar with major differences only in the amount found in the spine and pelvis and in the legs and feet. A more detailed study is in progress to determine exactly wherein the differences lie.

TABLE IX. Preliminary Data on the Distribution of ^{239}Pu in the Whole Body of a US Transuranium Registry Case

Tissue	^{239}Pu Content (dis/min)	^{239}Pu Content (nCi)
Respiratory tract[a]	8 150	3.67
Liver	2 920	1.32
Kidneys	5	—
Spleen	90	0.04
Smooth muscle organs[b]	30	0.01
Striated muscle and skin[c]	320	0.14
Other soft tissue	40	0.02
Skeleton	2 940	1.32
Total	14 495	6.52

[a]Lung, trachea, tracheobronchial lymph nodes.
[b]Intestinal tract, urinary bladder.
[c]Muscle, skin, heart, tongue, ears.
[d]Brain, adrenals, prostate, eyes, pancreas, thyroid, pituitary.

TABLE X. Preliminary Estimates Comparing the Distribution of ^{241}Am and ^{239}Pu in Two Whole Skeletons

Skeletal Units	Fraction of Total Skeletal Deposition (%) ^{241}Am	Fraction of Total Skeletal Deposition (%) ^{239}Pu
Head	14.1	14.3
Spine and pelvis	17.8	28.7
Shoulder and rib cage	9.0	8.3
Arms and hands	13.1	1.2
Legs and feet	46.0	37.5

Of the total whole-body deposition of ^{239}Pu in the latter case, 6.52 nCi, 56%, remained in the lung and tracheobronchial lymph nodes; 44% (2.86 nCi) was distributed throughout the systemic

*This information provided by J. N. P. Lawrence, Health, Safety, and Environment Division, Los Alamos National Laboratory, Los Alamos, New Mexico, in December 1983.

system with 46% of this burden in the liver and 46% in the skeleton. The liver/skeleton ratio is in good agreement with ICRP Publication 30 recommended 45%/45% distribution.[5] A more detailed report of the measured soft tissue and individual bone values is in progress.

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DEPOSITION OF INHALED PARTICLES IN THE RESPIRATORY TRACT AS A FUNCTION OF AGE AT EXPOSURE

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The lung model initially recommended by the ICRP[1] was developed to be applied in the workplace. Thus, it used only adult values for anatomical and physiological input parameters, such as those dealing with tidal volume and breathing rate. To deal with environmental exposures of humans, the model was changed to accommodate such parameters as the population changes with age from 1 month to adulthood. The alterations required age-related input concerning the respiratory tract gross anatomy and respiratory physiology. Quantification of these parameters is not precise and is highly variable among individuals, but ample data are available to make acceptable estimates.

The wide use of the ICRP lung model[1] led us to generally follow its derivation for extrapolation from adults to children, realizing that much sophistication has been applied to the respiratory tract anatomy and physiology since its publication in 1966. We chose to use Landahl's basic approach,[2] which incorporates much of Findeisen's original work,[3] utilizing a respiratory tract divided into only 11 airway segments. Weibel[4] and Yeh and Schum[5] have recently suggested the use of 23–25 airway segments, with individual branching angles for each segment. The Landahl model divides the respiratory tract into more broader segments by radius, length, and volume than do some of the newer models. Landahl[2] also used constant branching and gravitational angles throughout his calculations. Our major goal was to develop a respiratory tract deposition model that would accommodate age 1 month to adulthood as an initial step in calculating radiation dose following inhalation.

Deposition in each of the airways of the respiratory tract is by the forces of inertia (impaction), gravitation (sedimentation), and diffusion. The importance of each of these forces will differ according to particle size, airflow, and dimensions of the airway. Approximations of the deposition