

The Microdistribution and Long-Term Retention of Plutonium-Nitrate in the Respiratory Tracts of an Acutely Exposed Plutonium Worker and Experimental Beagle Dogs

Christopher E. Nielsen, Dulaney A. Wilson, Antone L. Brooks, Stacey L. McCord, Gerald E. Dagle, Anthony C James, Sergei Y. Tolmachev, Brian D. Thrall and William F. Morgan



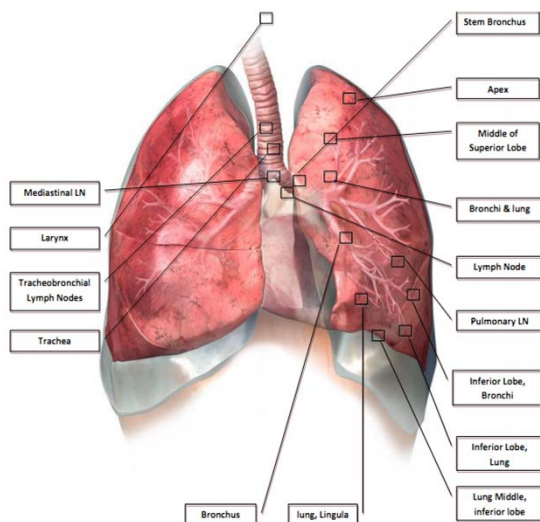
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ABSTRACT

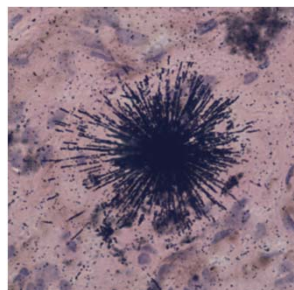
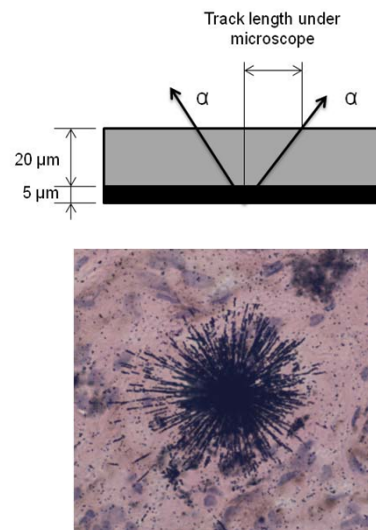
The distributions of long-term retained soluble plutonium-nitrate [$^{239}\text{Pu}(\text{NO}_3)_4$] deposited in the lungs of an accidentally exposed nuclear worker (Human Case 0269) and in the lungs of experimentally exposed beagle dogs with varying initial lung depositions were determined via autoradiography of selected histological lung, lymph node, trachea, and nasal turbinate tissue sections. Human Case 0269 had an estimated intake of 58kBq. Bioassay and radiochemistry data indicated that 2% of the initial deposit remained bound in the tissues at the time of death.

These studies showed that both the human and dogs had a non-uniform distribution of plutonium (Pu) throughout the respiratory tract. Fibrotic scar tissue effectively encapsulated a portion of the Pu and prevented its clearance from the body or translocation to other tissues and diminished dose to organ parenchyma. Alpha radiation activity from deposited Pu in Human Case 0269 was observed primarily along the pleura. In both the human case and beagle dogs, the appearance of retained Pu within the respiratory tract was inconsistent with current biokinetic models of clearance for soluble forms of Pu.



METHODS

Autoradiography – Used to record both the histological location and activity in sections of tissues. A photographic emulsion is used to make the image. Development of latent image shows the pattern of distribution of radioactive elements and modification of pattern by specimen structures.



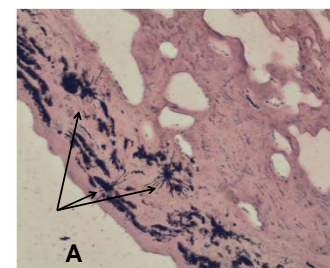
Particle Localization - Using the following lung compartments, the distribution and particle location of alpha stars were characterized with respect to the pulmonary sites identified below:

- Bronchovascular interstitial tissue of the bronchi
- Interstitial tissue of conducting bronchioles
- Intersitium of the parenchyma
- Lumen of conducting airways
- Non-Parenchymal scar
- Parenchymal scar
- Lymphoid tissue
- Pleura

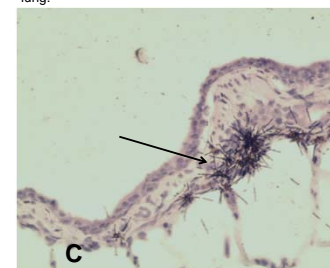
RESULTS

Table 1. Plutonium aggregate sizes for Human Case 0269

Lung Compartment	Total Frequency by Size (Number of Tracks)			
	2-10	11-20	>20	Total
Bronchovascular Interstitial Tissue of Bronchi	0	0	0	0
Interstitial Tissue of Conducting Bronchioles	0	0	1	1
Intersitium of Parenchyma	5	1	0	6
Lumens of Airways/Parenchyma	1	0	0	1
Lymphoid Tissue	2	0	0	2
Non-parenchymal Scar	0	0	0	0
Parenchymal Scar	28	18	5	51
Pleura	1	2	1	4
Total	37	21	7	65



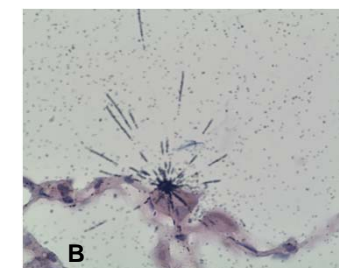
Autoradiographs from USTUR Case 0269. A. shows numerous alpha stars and cigarette residue "bound" by connective scar tissue in the visceral pleura of the lung.



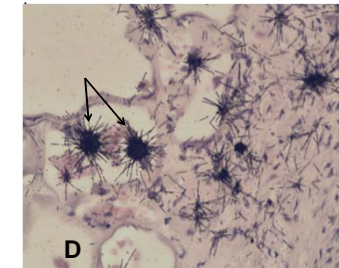
Autoradiographs from beagle dogs. C. alpha star aggregate of alpha activity localized within connective tissue along the pleura.

Table 2. Plutonium aggregate sizes for selected beagle dogs

Lung Compartment	Total Frequency by Size (Number of Tracks)			
	2-10	11-20	>20	Total
Bronchovascular Interstitial Tissue of Bronchi	9	5	0	14
Interstitial Tissue of Conducting Bronchioles	54	16	0	70
Intersitium of Parenchyma	85	66	1	152
Lumens of Airways/Parenchyma	35	0	0	35
Lymphoid Tissue	253	20	6	279
Non-parenchymal Scar	4	0	0	4
Parenchymal Scar	122	29	52	203
Pleura	47	43	0	90
Total	609	179	59	847



Autoradiographs from USTUR Case 0269. B. Plutonium engulfed by alveolar macrophages located on alveolar septa.



Autoradiographs from beagle dogs. D. Alpha star aggregate of plutonium-laden macrophages localized within parenchymal scar.

CONCLUSIONS

This study provides evidence that there is a prolonged retention of a small fraction of Pu sequestered in the pulmonary tissues following acute inhalations of Pu-nitrate aerosols. Sequestration of the remaining Pu was observed in a human subject as well as in several experimental dogs. This is sufficiently important to both cancer risk and radiation safety that it should be reflected in the dosimetry models for inhaled Pu-nitrates and possibly other relatively soluble forms of Pu. Prolonged retention may increase the average absorbed lifetime dose to the lung by several orders of magnitude than would be expected following current ICRP models.