FACTSHEETS

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CENTER FOR HUMAN RADIOBIOLOGY

Fact Sheet on

Plutonium Autoradiography

The Center for Human Radiobiology has exhumed 3 of 18 terminally ill persons injected intravenously with plutonium 30 years ago. The microscopic distribution of plutonium in the bone of one case has been studied extensively using autoradiography. This woman was 18 years old when injected and died 519 days later from the effects of Cushing's Syndrome contracted at about age 14. The autoradiographs show a non-uniform distribution of plutonium with deposits on the existing bone surfaces, on buried surfaces and in the volume between the existing and buried surfaces.

Plutonium concentrations

Plutonium concentrations measured in bone trabeculae are shown in the table below. The existing surface data refer only to the surfaces of bone which cover buried deposits of plutonium.

	Average ^{239}Pu concentration		
Bone	Buried surface pCi/cm^2	Existing surface pCi/cm^2	Volume pCi/cm^3
Cervical vertebra	4.6	0.47	160
Lumbar vertebra	4.1	0.32	89
Thoracic vertebra	-	0.26	120
Iliac crest	3.4	0.33	56
Pubis	2.9	0.63	100
Proximal humerus	2.6	0.29	67
Proximal femur	2.3	0.41	64
Mean for all bones	3.3	0.39	94

The difference of about 10 times between the buried and existing surface concentrations emphasizes the non-uniformity of deposition. The buried deposits are believed to date from the time of injection whereas the existing surface plutonium was probably laid down later, when the plasma concentration was low.

Burial depth

By covering the surface with new bone, appositional remodeling shields the surface cells from irradiation. The thickness of the deposit tells how effective this shielding is. The following table gives values for the bones listed above.

	Depth, μm	
Bone	Range	Average
Cervical vertebra	18— 86	54
Lumbar vertebra	14—120	57
Thoracic vertebra	27— 76	50
Iliac crest	31—100	50
Pubis	31—160	60
Proximal humerus	21— 80	40
Proximal femur	15—110	49

Average ± standard error of all measurements: 52 ± 2

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The range of ^{239}Pu alpha particles in bone is 23 μm. The depth values show that while some alpha particles from the buried deposits will escape the bone surface only a small fraction of the total will. Dosimetrically, the buried surface deposits may be ignored despite their great intensity.

Dosimetry

Dose rates are given below for the existing surface and volume deposits. They are averages throughout a 10 μm thick target tissue layer assumed to line the endosteal bone surface. Since volume deposits occur at sites of appositional remodeling but nowhere else only a portion of the target tissue will be irradiated by them. This must be taken into account when determining the average endosteal dose rate in a particular bone or throughout the skeleton. This may be done by multiplying the volume deposit dose rate by the fraction of bone surface which has been remodeled. This product added to the rate for surface deposits gives the average for the skeletal region in question.

	Dose rate, mrad/day			
Bone	Surface deposit	Volume deposit	Fraction remodeled	Average dose rate, mrad/day
Cervical vertebra	40	9	0.58	45
Lumbar vertebra	27	5	0.25	28
Thoracic vertebra	22	6	0.32	24
Iliac crest	28	3	0.50	30
Pubis	53	5	0.44	55
Proximal humerus	25	4	0.17	26
Proximal femur	35	4	0.12	35

The surface deposits contribute 90% or more of the average dose rate. As burden time increases the surface deposit is expected to contribute a smaller and smaller fraction of the total dose rate. From this standpoint the burden appears to be "young".

Other cases

Autoradiographs and microradiographs have been made of bone sections from the two other exhumed plutonium cases. The autoradiographs from one revealed that extensive plutonium redistribution and uranium deposition had occurred in the grave. Because of this no additional autoradiographs will be made and no autoradiographic data will be collected. The second case had been cremated and the skeleton broken up. Fragments of compact and cancellous bone which are large enough for easy embedding and sectioning are present although the bones from which they came cannot be identified. Microradiographs show innumerable microfractures throughout the sections due to the distortion of the bone when ashed. It appears that some useful autoradiographic data can be collected from this case. This one is especially interesting since the man survived 21 years after injection and should show the late distribution of plutonium.