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CENTER FOR HUMAN RADIOBIOLOGY

Fact Sheet on

Microscopic Radium Distribution and Dosimetry

Microdosimetry of Paranasal Sinus and Mastoid Air Cell Carcinomas

Among radium cases, there is an unusually high risk of carcinomas in the paranasal sinuses and mastoid air cells. But, little is known about the dose delivered to the epithelial cells at risk because the target cell locations and the amounts of radioactivity producing the dose are not well known. This problem is complicated by the fact that two sources of radioactivity are present: Radium and its daughter products lodged in bone and radon and its daughter products contained in the air spaces and on the surfaces of the mucosal membranes. The latter source is assumed to be more important than the former, but there are no quantitative dosimetric data to support this. Furthermore, radon concentrations in the sinus and mastoid air spaces cannot be measured during life, or with great reliance post mortem.

Two efforts are now being made to solve these problems. The first is a histological study of the mucosal linings in the paranasal sinuses and mastoid air cells. From this, we expect to determine the distributions of cell to bone surface and cell to epithelial surface distances so that practical microdosimetric calculations can be carried out given the distributions of radioactivity. Second is an autoradiographic study of the terminal distribution of radium in the walls and septa of the mastoid air cells and paranasal sinuses. From this and surface to target cell distances, we expect to determine the terminal dose rate to target cells within range of the bone surface due to radioactivity deposited in the bone.

Histological study of a low level radium case and several unexposed individuals is now being carried out. The observations, so far, show the target cells to reside exclusively in the epithelial membrane atop the lamina propria. Glands at intermediate distances are absent. The thickness of the lamina propria varies widely within a particular site and between sites as well. In the mastoids, the epithelial membrane may be as close to the bone surface as a few microns or as far from it as several hundred microns. In the frontal sinuses, the separations observed so far exceed the alpha particle ranges of radium and its daughter products. These data indicate that radon in the air space and radon daughter products on the epithelial membrane would be the important source of radiation dose in the frontal sinuses, but in the mastoid air cells, significant radiation dose could be produced by radium and its daughter products deposited in bone.

Autoradiographs are being made and evaluated for the mastoid regions in 14 cases with mean skeletal doses in excess of 1500 rad. Autoradiographs of 7 of these, 3 with mastoid carcinomas on the side opposite the sampling site and one with a sphenoid carcinoma, have been examined. All show a nearly complete absence of hot spots in the air cell septa, but substantial hot spot activity in the lateral and medial walls of the temporal bone. It, thus, appears that formation of

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the mastoid air cells had ceased by the age of first exposure (14-21 years) and that bone remodeling was absent. Dosimetrically, this means that the mastoid mucosa were irradiated almost exclusively by a diffuse deposit rather than by diffuse and hot spot deposits, the common situation throughout the skeleton.

Microdosimetry at Endosteal Bone Surfaces

Models of bone tumor induction proposed by Marshall and Groer predict a lower dose to bone cells at endosteal surfaces than expected from autoradiographic measurements. Because of its low spatial resolution, autoradiography provides only an indirect measure of endosteal dose rate and may be the reason for the discrepancy. To improve upon this, direct measurements of the energy released from bone surfaces are now being made using alpha particle spectrometry. Because of its high spatial resolution, spectrometry also allows us to determine the distribution of radium as a function of depth below the bone surface and, thus, to test a specific hypothesis explaining the disagreement between predicted and observed dose: The presence of a layer of bone, adjacent to the surface which is depleted in its radium content. To date, we have found evidence of depleted layers in some bone samples and evidence of layers with enhanced concentrations in others. The relative frequency with which these types occur is yet to be determined.

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