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Long-Term Radiation of Bone Following Administration of C^{14}-Bicarbonate.* (22539)

HOWARD E. SKIPPER, LINDA SIMPSON, AND MARTELIA BELL.
Kettering-Meyer Laboratory (Affiliated with Sloan-Kettering Institute), Southern Research Institute, Birmingham, Ala.

Studies on distribution, turnover, and long-term retention of C^{14} (from $C^{14}O_3$) in animal tissues have indicated that from the standpoint of C^{14} radiation hazard, the bone is perhaps of greatest concern(1-5). For several months after injection of 18 μc of $NaHC^{14}O_3$ (a 50 mc man-equivalent), the radiation doses in "active" areas of long bones of mice were greater than the "tolerated dose limit" of 0.05 roentgen equivalent physical (rep) per day. Although it is apparent that one cannot extrapolate directly from animal results to man without some quantitative results on the latter, it seems important to obtain rather extensive data with regard to long-term retention of C^{14} in bones of animals and to estimate radiation being received by the most active areas of such bones. Such data might be of value in rough approximation of the hazard involved in use of C^{14}, and with availability of some human data correlations could be made.

The present paper is a brief report extending and confirming earlier reports from this laboratory(2,3) on long-term retention of C^{14} from bicarbonate by long bones of mice and appropriate radiation calculations.

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Experimental. Each of a group of adult CFW strain mice (3 months of age) was administered intraperitoneally 100 μc of C^{14}-bicarbonate. These animals were sacrificed as indicated in Table I. A femur and humerus were taken from each animal for oxidation and activity assay in a gas phase Geiger counter(6) which had been calibrated against a Bureau of Standards $BaC^{14}O_3$ standard and shown to give results extremely close to the absolute C^{14} content. Corresponding bones from the same animals were fixed in alcohol, embedded in plastic, and ground to provide the desired cross section, and subsequently autoradiogrammed on No-Screen X-ray film. The "active" volume of each bone was calculated from the individual autoradiograms. The average length and width of the parallel autoradiogram lines were measured with a filar micrometer and the "active" bone volume calculated using the procedure and assumptions previously described (3). Based on the total activity determinations on corresponding bones of the same mouse, calculations have been made of the total activity per cmm of "active" bone and the degree of radiation (rep) in "active" bone. Results of these efforts are presented in Table I along with previously reported results(3).

TABLE I. Calculations on Radiation Received by "Active" Bone at Periods following a Single Injection of C^{14}-Bicarbonate (100 μc/Mouse).

Period after inj.	Bone	Specific activity (μc/mole C)	Avg radiation in "active" bone (rep/day) New data	J.B.C. 189 159, 1951*
1 wk	Femur	1.5	.6	
	Humerus	1.2	.4	
2 "	Femur	1.5*		.9
1 mo	Femur	1.0	.2	
	Humerus	.8	.2	
4 "	Femur	.5	.1	
	Humerus	.5	.2	
6 "	Femur	.6*		.2
	"	.5*		.2
	"	.4*		.2
8 "	Femur	.5		
	Humerus	.3	.08	
12 "	Tibia	.2		
	Humerus	.1	.03	
17 "	Tibia	.03	.008	
21 "	Tibia and humerus	.02	.005	

* Previously reported values corrected ($\times$ 5.5) because of differences in level of C^{14} inj. (18 μc *vs* 100 μc) included for comparison with present data.

These results are plotted in Fig. 1. No gross evidence of bone damage was observed in any of the animals employed in this investigation.

Discussion. It can be seen from the data presented in Table I that the specific activity of bones from mice injected with a single dose of 100 μc of C^{14}-bicarbonate drops continuously with time, until at 21 months the activity is extremely low (0.02 μc/mole of carbon, ca. 1% of the bone specific activity at one week). Agreement of the present data with previously published data is good. After injection of 100 μc (a 280 millicurie man-equivalent) approximately one year was required for the radiation being received by the "active area" of the bone to drop to the maximum tolerated level for man (0.05 rep/day). This should not be construed as evidence that C^{14} is a particularly hazardous isotope since

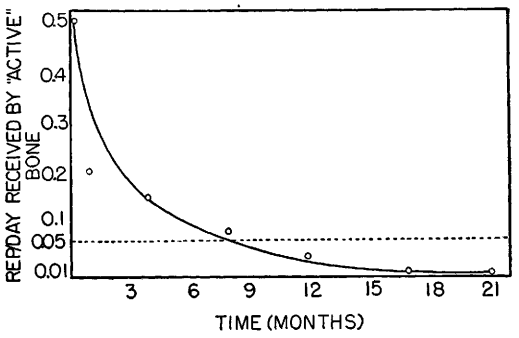

FIG. 1. Calculated radiation received by area of bone where C^{14} from $NaHC^{14}O_3$ has localized at varying periods following single inj. of 100 μc (a 280 mc man-equivalent). Dotted line indicates maximum permissible daily dose.

it is difficult to visualize accidental inhalation of millicurie quantities of $C^{14}O_2$ in any ordinary laboratory operation.

These data would seem to suggest that, for specially authorized human experimentation (in the instance of compounds in which the biological fate of the carbon isotope is $C^{14}O_2$), the present allowable doses of C^{14} are not too high.

Summary. Studies have been carried out on retention of C^{14} from labeled bicarbonate in the bones of mice. A single dose of 100 μc per mouse (a 280 millicurie man-equivalent) provided daily radiation of the most active areas of the long bones of above 0.05 rep/day for a period of approximately one year.

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