TRANSLOCATION OF ^{90}Sr FROM MATERNAL SKELETON TO PROGENY DURING GESTATION AND LACTATION*

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Abstract—The fractional translocation of ^{90}Sr to progeny during gestation and lactation was determined in five adult Beagles previously fed a diet containing 1.1 or 3.3 μCi ^{90}Sr/g Ca. These proven dams were fed approximately 4 or 12 μCi ^{90}Sr per day for about one year during adulthood, and after 85, 102, 150, and 286 days on non-radioactive food they were re-bred. The body burdens of the dams and/or their litters were determined *in vivo* by monitoring of the (^{90}Sr + ^{90}Y) bremsstrahlung at the time of breeding, whelping, during nursing, and at weaning, at which time the animals were sacrificed and their body burdens radiochemically confirmed. From 10–30% of the maternal skeletal burden of ^{90}Sr was lost by the combined influence of gestation and lactation. The fractional loss of ^{90}Sr appeared to have been dependent primarily on litter size, but may also have been influenced by the length of time from acquisition of the body burden to breeding. At birth the ^{90}Sr content of the litters represented less than 1% of the initial maternal body burdens and increased to more than 10% at weaning. The body burdens of the litters at weaning accounted for nearly 30% of the maternal loss. These data suggest that the evaluation of possible radiation hazards to the newborn from biospheric contamination requires knowledge of the maternal contribution to the body burden of the offspring as well as that from dietary sources.

INTRODUCTION

Theoretical calculations of ^{90}Sr and ^{89}Sr dose in the human fetus and infant have been limited severely by the lack of pertinent experimental data.(1) Of utmost importance is the question of the fractional translocation of the radiostrontium body burden from maternal bone to progeny. Further, the contribution of maternal nursing toward the body burden of the young relative to that acquired during gestation would have to be considered. The study on the effects of continually fed ^{90}Sr in the Beagle, currently under way at the Radiobiology Laboratory, University of California at Davis, provided a unique opportunity to obtain such comparable data in the dog.

METHODS AND MATERIALS

A series of five proven Beagle dams were fed approximately 4 or 12 μCi ^{90}Sr per day for about one year; they were then fed non-radioactive food and kept in outdoor pens. The diet contained one percent calcium with a Ca/P ratio of about 1.5; the average maintenance intake per day was about 400 g food. As the dogs came into estrus they were rebred. Breeding times were at 85, 102, 150, and two at 286 days after acquiring their body burdens.

The respective body burdens of the dams and their litters were determined *in vivo* by total body counting of the (^{90}Sr + ^{90}Y) bremsstrahlung at the time of breeding, whelping, during suckling, and at weaning of the litters. Some of the animals were sacrificed and their body burdens determined radiochemically.

RESULTS AND DISCUSSION

In Table 1 are summarized the losses in maternal body burdens.

From 10–30% of the maternal skeletal burdens of ^{90}Sr was lost by the combined effect of gestation and lactation. In some cases little or no loss in body burden could be detected during

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Table 1. Loss of Maternal ^{90}Sr due to Gestation and Lactation

Time to breeding (days)	Body burden (μCi ^{90}Sr)			% body burden lost		
	Initial	Whelping	Weaning	Total	Gestation	Lactation
85	10.8*	9.1	8.0	26	16	10
102	35.5†	32.9	24.6	29	5	24
150	5.4*	5.4	4.5	17	n.d.‡	17
286	31.2†	31.2	26.2	16	n.d.‡	16
286	16.9†	16.0	15.2	10	5	5

* 4 μCi/day.
† 12 μCi/day.
‡ Not detectable.

gestation and it is evident that most of the maternal losses occurred during lactation.

The losses in maternal body burdens should, of course, be corrected for the fraction of the ^{90}Sr which is normally lost by excretion. Since control or non-bred dogs were not available for this study, the data of Goldman, Powell and Young[2] on retention of ^{90}Sr in uniformly labeled Beagles were used to approximate the retention pattern in these dogs. Some of these data, together with the loss in body burdens due to gestation and lactation in this study, are shown in Fig. 1. Thus, if one assumes that the dams' skeletons were essentially uniformly labeled (^{90}Sr/Ca ratios in the different bones of one dam studied did not vary by more than a factor of two), about 6% of the initial body burden would be lost per 100 days—at least for the first year following the end of ^{90}Sr feeding. It is evident from Fig. 1 that during gestation

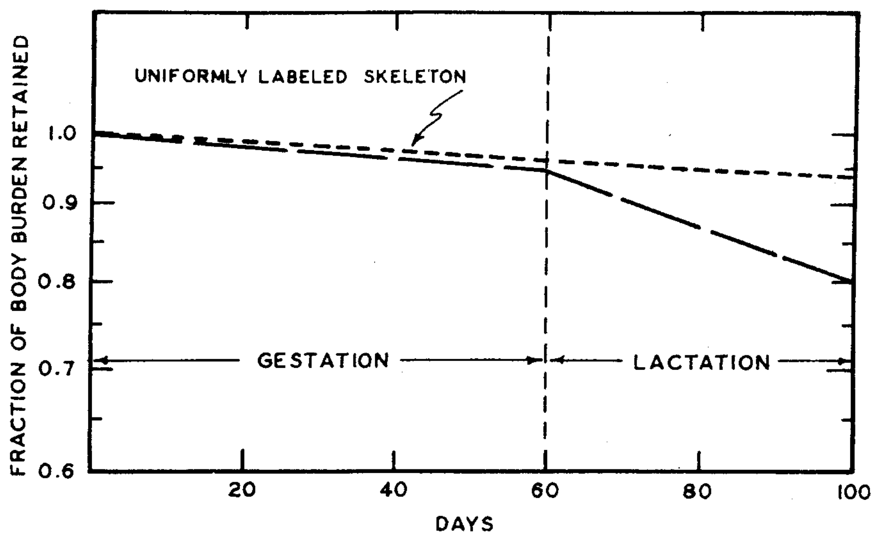

Fig. 1. Whole body retention pattern of ^{90}Sr in uniformly labeled Beagle skeletons, compared to body losses during gestation and lactation.

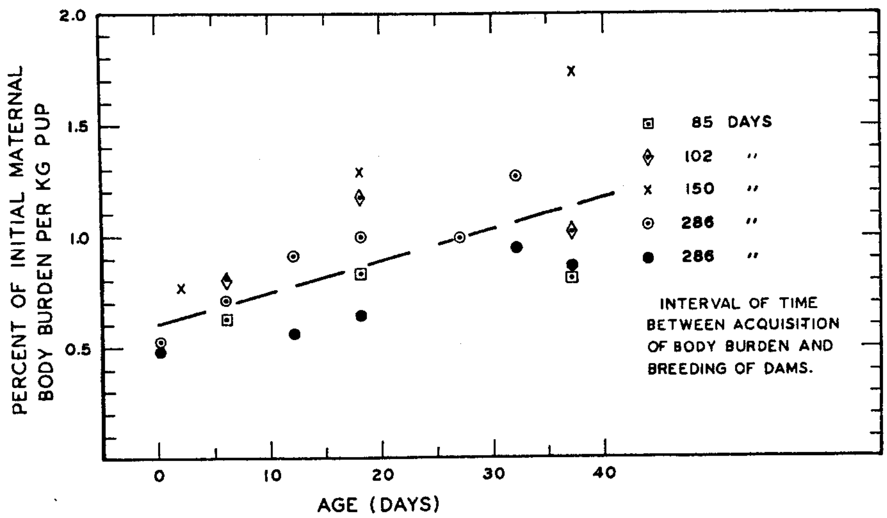

FIG. 2. ^{90}Sr pup body burdens expressed as percent of initial maternal body burden per kilogram of pup body weight.

the slope of the curve did not vary significantly from that of the uniformly labeled bone and that almost all the decrease in body burden was seen during the period of lactation and appears to be primarily a function of litter size.

Table 2 summarizes the accumulation of ^{90}Sr in the litters of pups expressed as percentages of the initial maternal body burdens and of the maternal radiostrontium losses. At birth the ^{90}Sr content of the litters represented about 1% of the initial maternal body burdens, and at weaning the pups had accumulated as much as 13% of the maternal body burdens. The pup

Table 2. Pup Body Burdens from Birth to Weaning

Time to breeding (days)	No. pups born/weaned	μCi ^{90}Sr/litter			% of maternal body burden		
		0–6 days	18 days	38 days	Initial 0–6 days	Initial 38 days	Total loss 38 days
85	6/6	0.1	0.3	0.7	1	6 (~1/pup)*	25
102	7/7	0.8	2.0	3.1	2	9 (~1/pup)	31
150	5/5	0.1	0.3	0.7	2	13 (~3/pup)	80
286	4/3	0.1 (4 pups)	0.5 (3 pups)	1.4 (3 pups)	~0.3	4 (~1/pup)	28
286	5/1	0.1 (5 pups)	0.1 (1 pup)	0.3 (1 pup)	~0.6	2	18

* Expressed as per cent of maternal body burden per pup.

body burdens at weaning accounted for about 30% of the maternal losses. In the dam bred 150 days after acquiring its body burden, the pups contained about 80% of the maternal loss. This may be due in part to the relatively small loss, as well as difficulties of *in vivo* bremsstrahlung measurement on unanesthetized dogs with small body burdens. It is pertinent to mention here that the average body weight of Beagle pups is about 200 g at birth, and at weaning the body weight is about 1–1.5 kg. Total body calcium is about 1 g at birth and 10 g at weaning. As seen from the values in parentheses in Table 2, approximately 1 to 3% of the initial maternal body burden was transferred to each pup at weaning.

Figure 2 shows the data normalized to 1 kg of pup and further indicates this relationship. The line was drawn through the average of all values. Thus, from birth to 38 days there is an approximate increase of 0.01% of the initial maternal body burden per kilogram of pup per day. At birth a litter of 5 pups (about 1 kg) would contain approximately 0.5% of the initial maternal body burden (or about 0.1% per pup); at weaning this value increases to more than 1%, the same tenfold-increased mineralization as noted above.

These data are in essential agreement with the theoretical prediction of Mays[3] that a former ^{90}Sr dial painter of Czechoslovakia, Switzerland or Poland might transfer roughly 0.6% of her body burden to her newborn child.

These limited data reported here on Beagle dogs suggests that the evaluation of possible radiation hazards to newborn pups requires not only knowledge of dietary contamination, but also the extent of maternal transfer via gestation and nursing. Further, in the case of significant contamination of the maternal skeleton the elimination of breast feeding should be considered.

ACKNOWLEDGEMENTS

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