Effects of Age and Mode of Ingestion on Absorption of Plutonium.*† (24164)

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Gastrointestinal absorption and distribution of plutonium in the rat has been studied in detail(1-3). In most experiments, absorption was determined for young adult animals. The gavage method of administration has been employed extensively since it permits accurate calibration of the dose delivered. From the standpoint of personnel hazard however, stomach intubation does not adequately represent the conditions of accidental oral ingestion where the oral cavity and esophagus may also be exposed to the radioisotope. Further studies on plutonium metabolism showing the influence of age and method of oral administration on absorption are presented here.

Methods. Rats were of the Sprague-Dawley strain, ranging in age from 1 to 84 days. The very young animals were gavage fed using a ¼ cc syringe fixed with a length of plastic intravenous tubing drawn out to about the diameter of a 27 gauge needle. Each rat received approximately 100 μg of plutonium by gavage in 50 μl of a pH 2 nitric acid solution. At least 5 rats were fed in each age group. After 21 days the rats were sacrificed and plutonium content determined in liver, lung, carcass and, in some animals, total bone and soft tissue. Lungs of all rats were analyzed to determine if exposure had been intratracheal rather than intragastric. The young were returned to the dams after feeding and maintained in the usual manner until sacrificed. Adult rats were used in the studies to show the effect of the method of oral administration on absorption. Those rats administered Pu^{239} directly on the tongue received 1.4 μg of plutonium in 5 μl of either a 0.1 N or 2 N nitric acid solution. Animals were sacrificed after 7 days and the head, liver, and total skeleton analyzed for plutonium content. Rats fed plutonium in drinking water were exposed for 24 days to pH 2 water containing 66 μg of plutonium/liter. Previous studies showed percentage of the dose absorbed did not vary within a dose range of 10^{-5} μg/ml to 1 μg/ml(2). Daily consumption amounted to about 1 μg after correcting for loss due to dripping from water bottles. Samples taken at sacrifice included liver and skeleton.

Results. Gastrointestinal absorption of plutonium at several ages is shown in Fig. 1. In day-old rats absorption was 85 times that of the adult(2). The amount absorbed dropped abruptly in 21-day-old rats to near adult levels. The % absorbed varied considerably among animals in this group, possibly because of dietary and metabolic changes associated with this age of weaning. After age 30 days gastrointestinal absorption was not significantly different from the adult level, except for the unexplained high absorption found in the 56-day group. Plutonium distribution in the 7-day-old rat was essentially the same as that reported for the adult(2). Of the total plutonium retained, 80% was in the skeleton, 15% in the liver and 5% in the soft tissues.

Results of the study of plutonium absorption and distribution following oral administration are presented in Table I. Total absorption after exposure to the tongue was approximately 20 times lower than has been reported for similar solutions fed intragastrically(2). Holdup of plutonium in the mouth of these animals was still appreciable 7 days after exposure, especially for the more acid solution. On examination at sacrifice, the oral cavity showed no gross damage due to the 2 N acid. Absorption after drinking water containing plutonium for 24 days was in close agreement with results obtained from previous gavage feeding experiments(2).

Discussion. Conclusions based on extrapo-

* Work performed under contract between Atomic Energy Com. and General Electric Co.

† The author wishes to acknowledge the help and guidance of Dr. Roy C. Thompson and technical assistance of Mrs. Joan Hess, Mrs. Margaret Lawson and personnel of Biological Analyses Operation.

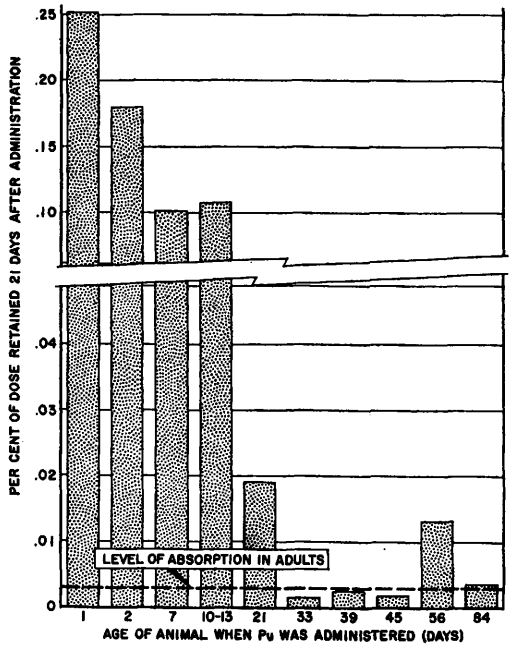

FIG. 1. Gastrointestinal absorption of plutonium by rats of different ages.

lation of plutonium absorption in the immature rat to any particular age in the human infant are of doubtful significance because of the uniquely long pre-pubertal period in man compared to other mammals. During this early development little correlation exists between man and rat in age-growth relationships by which some comparison might be made(4). However, these results do give a quantitative measure of an enhanced absorption that exists during early development and differentiation of the intestinal tissues. Of interest in this regard is the apparent permeability of the newborn animal intestine to some of the proteins present in the colostrum. Histological studies have shown globulins absorbed without change from the intestine of the calf 24 to 48 hours after birth(5). Enhanced absorption of plutonium by immature rats may be further evidence of this increased intestinal permeability to relatively complex materials. Of further interest is the observation that colostral protein is not absorbed appreciably by rats after age 21 days(6). Plutonium absorption at this age was found to be markedly decreased to near adult levels.

The only suggestion of an increased hazard from ingested plutonium due to exposure of the oral cavity and esophagus lies in the prolonged retention of an appreciable fraction of administered plutonium in the head. This was observed only following the application of solutions of high plutonium concentration directly on the tongue, and was not reflected in any increased absorption and deposition in bone. Under usual conditions of exposure it seems reasonable to conclude that exposure of the oral cavity and esophagus will lead to no increase in the hazard.

TABLE I. Absorption and Distribution of Orally Administered Plutonium (% of Administered Dose per Tissue).

Tissue	Single dose on tongue		24 days in drinking water, pH 2
	2 N HNO_3	.1 N HNO_3	
Bone	.003	.005	.002
Liver	.003	.002	.006
Head	.4	.08	

Summary. The effect of age on gastrointestinal absorption of plutonium was determined for rats over the range 1 to 84 days of age. Absorption for 1-day-old rats was 85 times that reported for the adult. This dropped to near adult levels in the 21-day-old weanlings. Plutonium distribution in the 7-day-old rat was essentially the same as that found for the adult. Absorption of plutonium applied directly to the tongue or fed in drinking water did not differ significantly from absorption following gavage feeding. It was concluded that the hazard of ingested plutonium is not increased when exposure of the oral cavity and esophagus is involved.

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Received May 14, 1958. P.S.E.B.M., 1958, v98.