JUN 24 1968

BNWL-SA- 19 T5

MASTER

THE UPTAKE, DISTRIBUTION AND EXCRETION OF PROMETHIUM IN HUMANS
AND THE EFFECT OF DTPA ON THESE PARAMETERS† #

(a) H. E. Palmer, G. H. Crook, M.D.*,
(b) and I. C. Nelson

~~Battelle Memorial Institute~~
~~Pacific Northwest Laboratory~~

~~Richland, Washington~~

Large scale separation of ^{147}Pm fission product waste and preparation of the material for several applications constitutes a potential source of radiation exposure to workers in this field. [In order to form a basis for radiation exposure limits and to determine the dose from accidental exposure, the uptake, retention, distribution and excretion of promethium must be known.]

(under direction of
H.E.H.)

An experiment using ^{143}Pm (1) and human volunteer test subjects was performed to determine these metabolic parameters. Whole body counting techniques and urinary and fecal measurements were used to study the course of the promethium following both intravenous and oral administration of $^{143}\text{PmCl}_3$ to humans. When this experiment is completed, the results will provide correlation between body burden and urinary excretion of promethium which should be useful in evaluating cases of accidental exposure to ^{147}Pm .

Promethium-143 decays by electron capture and subsequent gamma ray emission. The gamma ray energy is 0.74 MeV and is excellent for whole body counting purposes. The ^{143}Pm used in this experiment was prepared by Oak Ridge National Laboratory using high energy proton irradiation of enriched $^{144}\text{Nd}_2\text{O}_3$ (94.4%). A small amount of ^{144}Pm was also formed. The ^{143}Pm was

† This report is submitted only for the purpose of clearance for oral presentation at the Health Physics Meeting. It will not be published in this form.

* Hanford Environmental Health Foundation, Richland, Washington.

(a) & (b) Battelle Memorial Institute
Pacific Northwest Laboratory
Richland, Washington

This paper is based on work performed
under United States Atomic Energy
Commission Contract AT(40-1)-1890.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

84

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

separated from the irradiated neodymium at Battelle-Northwest by an ion exchange method using Dowex 5-X⁴ fine mesh resin and eluting the ¹⁴³Pm essentially carrier free with 0.25 N α -hydroxybutyric acid at a pH of 4.6. The separated ¹⁴³Pm was sent to Abbott Radiopharmaceutical Laboratories where it was sterilized, dissolved in isotonic saline solution, made acidic to pH=3, and pyrogen tested in rabbits.

Localization and distribution of the ¹⁴³Pm within the body was followed using a shadow shield whole body counter.⁽²⁾ A 2-inch wide slit system over the 9-3/8" diameter NaI(Tl) detector permitted differential scanning of the subject as he traveled under the crystal. Whole body counts were made periodically to determine the total ¹⁴³Pm remaining in the body and these counts will continue for at least one year. Urine, feces and blood samples were collected and analyzed for ¹⁴³Pm from each volunteer for periods up to 85 days after injection of the ¹⁴³Pm.

The ¹⁴³PmCl₃ was administered to eight normal human volunteers by physicians of the Hanford Environmental Health Foundation. Six volunteers received approximately 0.1 μ Ci of ¹⁴³Pm intravenously and two volunteers received an oral dose of 10 μ Ci.

A typical distribution of ¹⁴³Pm in a human volunteer with time following intravenous administration is shown in Figure 1. The uptake in the liver is very rapid with most of the liver fraction arriving there within 90 seconds. A rough measure of the amount in the liver was made and found to be between 40 to 50% of the injected dose. Whole body scans after 24 hours show that the distribution in the body remains unchanged up

to 180 days after injection with the exception that the peak over the bladder area disappears during the second day. The ^{143}Pm which does not go immediately to the liver appears to remain in the blood for a short time and gradually deposit in the bone. The total estimated content of ^{143}Pm in the blood as a function of time obtained by analyzing periodic blood samples of a volunteer is shown in Figure 2. The ^{143}Pm activity was not detectable in the blood at 24 hours.

[The excretion of ^{143}Pm following intravenous injection is via both the urine and feces.] During the first week the amount excreted in the urine is 10 times that excreted in feces. The daily excretion in urine for 84 days following injection and in feces for 7 days after injection is shown in Figure 3. The rate of fecal ^{143}Pm excretion does not decrease as rapidly as the urinary rate excretion and results from a pig injected with the same ^{143}Pm solution by the Biology Department indicate that the fecal ^{143}Pm excretion will exceed the urinary excretion after a few weeks. Measurements of urinary excretion were not made after three months after injection because the content in the urine was near or below the detection limit of the counting method.

The retention of the ^{143}Pm as measured by the whole body counter agrees with the excretion results and is shown in Figure 4 as a function of time. An extrapolation of the retention curve between 20 and 184 days indicates the biological half-life of ^{143}Pm in the total body is greater than 1000 days. Whole body counts will be continued for at least one year so that the half life can be determined more accurately. Any redistribution

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

of the ^{143}Pm between liver, bone or other organs has not been detected in comparing periodic counts over the legs, liver and head of the volunteers.

Two volunteers orally ingested 10 μCi of the $^{143}\text{PmCl}_3$ solution mixed with orange juice. Subsequent excretion analysis showed that essentially none of the material was absorbed by the body and all of it was excreted in the feces. No activity was detected in the urine samples. After one week regular whole body counts showed there was no activity remaining in the body. However, a one hour count directly over the liver of one of the volunteers showed a liver content of about 0.0001 μCi . The ^{143}Pm content in the liver remained constant in subsequent counts up to a month later which confirmed that the activity was actually in the liver and not temporarily lodged in the G.I. tract. The uptake by this volunteer was estimated to be about 0.001% which agrees with the ICRP estimates of the uptake of Pm from ingestion. Promethium-143 activity was not detectable in the other volunteers and the uptake was probably less than 0.0005%.

Although the results of this experiment are not complete it appears that they agree with the results obtained in animal studies,⁽³⁾ but they disagree with the liver uptake parameters listed by the ICRP⁽⁴⁾. The ICRP Handbook lists the fraction from the blood to liver as 0.06, whereas this experiment shows this fraction to be 0.4 to 0.5. Further experiments are planned to determine if the distribution in the body after inhalation of soluble $^{143}\text{PmCl}_3$ is the same as that obtained from this injection experiment.

The Effect of DTPA on Excretion of Promethium in Humans

The effect of diethylenetriaminepentaacetic acid (DTPA) on the

excretion and retention of ^{143}Pm in humans was studied as a function of the time interval between the injection of ^{143}Pm and administration of DTPA. DTPA was given at different times to 8 subjects from 5 minutes before to 86 days after injection of ^{143}Pm . Figure 5 shows the urinary excretion of ^{143}Pm with time up to 6 days after injection for 6 subjects who were given DTPA according to the following schedule shown in Table I.

TABLE I
Schedule of DTPA Administration

<u>Subject</u>	<u>Time of administration of 1 gram DTPA relative to time of injection of ^{143}Pm</u>
1	5 minutes before
2	30 minutes after
3	1 hr, 5 hrs and 24 hrs after
4	1 hr, 24 hrs, 48 hrs, 72 hrs after
5	5 hrs after
6	24 hrs after

The excretion of the injected ^{143}Pm varied from 100% of dose for the case where DTPA was injected for 5 minutes before the ^{143}Pm injection to only 20% of dose when DTPA was administered 24 hours after the ^{143}Pm injection.

These { results indicate that DTPA is very effective in significantly reducing the body content of promethium when administered within about an hour after the internal deposition. } If the DTPA is given 5 or more hours

later, the body burden will decrease by only 50% or less.]

To study the effect of DTPA on long term internal depositions of promethium, DTPA was given to two subjects 80 days after a previous injection of ^{143}Pm . Urinary excretion measurements indicated that only about 5% of the body content of ^{143}Pm was excreted during the following week.

In following the excretion of ^{143}Pm from the body after DTPA administration, it was found that the whole body counting results always indicated a greater loss than did the excretion results. Since the ^{143}Pm in the liver is counted with a greater efficiency than that in the bones, these results indicate that much more of the ^{143}Pm that is extracted by the DTPA comes from the liver than from the bone. Further studies are needed to more accurately determine the relative excretion rates from liver and bone.

REFERENCES

1. T. M. Beasley and H. E. Palmer. "Production of Promethium-143 and -144 by Proton Irradiation." Pacific Northwest Laboratory Annual Report for 1966 Volume II: Physical Sciences, Part 2: Radiological Sciences, BNWL-481 2, p. 54. Pacific Northwest Laboratory, Richland, Washington. 1967.
2. H. E. Palmer and W. C. Roesch. "A Shadow Shield Whole-Body Counter," Health Physics, vol. 11, pp. 1213-1219. 1965.
3. B. O. Stuart. Preliminary Studies of Inhaled ^{147}Pm Perchlorate, HW-80500, p. 59. General Electric Company, Richland, Washington. January 15, 1964.
4. International Committee on Radiological Protection Recommendations. Report II, Permissible Dose of Internal Radiation, p. 202. Pergamon Press, New York. 1960.

DIFFERENTIAL SCAN OF ^{143}Pm IN TEST SUBJECTS AT VARIOUS TIMES
AFTER INJECTION

FIGURE 1

FIGURE 2
Percent ^{143}Pr Remaining in Blood Following Intravenous Administration

Daily Urinary and Fecal Excretions of Intravenously Injected
 ^{143}Pm

FIGURE 3

THE RETENTION OF ^{143}Pm IN HUMANS

FIGURE 4

THE EFFECT OF DTPA ON ^{143}Pm RETENTION IN HUMANS

FIGURE 5