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A REVIEW OF THE HUMAN PLUTONIUM INJECTION STUDIES*

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ABSTRACT

A review of the human plutonium injection studies reported by Langham (La50) was made by studying the Los Alamos Laboratory notebooks used to record and report the analytical results obtained from the intravenous administration of plutonium as a Pu+4 complex. This study was planned and executed in 1945 under wartime urgency. The results were needed to provide information on the behavior of plutonium in humans. The experiment was important for the following reasons:

1. To minimize the degree of uncertainty inherent in extrapolating the vast amount of animal experimental data to man.

2. To provide the best possible quantitative basis for the diagnosis of degree of exposure of personnel to plutonium.

3. To determine the degree of fixation of plutonium by man and establish criteria for the period of retirement from further exposure of workers having received a maximum permissible dose.

4. To provide more extensive and quantitative data on the deposition and excretion of plutonium by man as a basis for future consideration of maximum permissible body tolerance.

All of these objectives were met by the study and were based on urine, fecal, blood, and tissue samples analyzed at Los Alamos. The plutonium urine excretion model resulting from this study utilized samples collected over a short 138-day period. This model was extended to 1750 days by using additional urine data collected from two of the injected cases. These data and additional plutonium excretion data from three occupationally exposed workers were the basis for a power function model used to predict plutonium body burdens. This model has been used extensively to estimate workers intake of plutonium and is based on the employee's 24 hour urinary plutonium excretion at n days following exposure.

The inadequacies of the Langham power function model, at long times (20 yrs.) after intake of plutonium, have been demonstrated by the larger than predicted plutonium excretion in occupationally exposed workers.

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The data reported by Rundo (Ru 79) on two of the injected cases, at 10,000 days post-intake, support the conclusion that the power function model does not adequately describe the plutonium excretion beyond 5 years.

The Rundo data prompted the review of the original injection study notebooks for additional information which might add to our knowledge of the behavior of plutonium in humans. This review identified transcription errors in the urine data for four of the eleven injected cases recorded in the Los Alamos notebooks. It was also noted that available urinary excretion data, collected at days of 322, 394, and 474 post-intake on three cases, were not utilized to develop the power function model.

The urine results reported by Langham at 1600 days post-intake for two of the injection cases were also reviewed and found to be reported low because of the data reduction methods used at that time (1950). The impact of transcription errors and the additional data at 300 to 400 days is the subject to be presented in this paper.

The corrected and additional urine data, expressed as the per cent of the administered dose excreted per day for the injected cases, showed conclusively that the rate of plutonium excretion decreased continuously from the day of administration through 1600 days. The decrease was rapid and deviated significantly from a single power function model between 10 and 100 days. The corrected urine data points at day 80 and the additional results between day 300 and 400 days were very supportive of the data reported by Rundo at 10,000 days.

These data, including the results collected at 10,000 days, were used to develop a sum of three exponential models which indicated a slope of -0.000048 for the third exponential function from day 100 to 10,000 days post exposure. This slope is consistent with the plutonium excretion noted in plutonium workers urine data collected during a similar 10,000 day post exposure period.

The fecal results were also reviewed for their completeness and were found to be correctly recorded and reported. A three exponential model was also developed for the fecal data through day 10,000.

The integrated percentage of the total amount of plutonium excreted, using these exponential models over a 10,000 day period, is 35 per cent for urine and 15 per cent for fecal.

The significance of these additional plutonium data is as follows:

1. The excretion rates for plutonium following intravenous administration are predictably similar for the eleven cases studied.

2. The plutonuim excretion rates were very rapid from the first day and deviated from a single power function fit within the first 100 days.

3. The plutonium excretion in both the urine and feces was described by a sum of three exponentials model which also describes the plutonium excretion noted in plutonium workers who received their exposures 10,000 days ago.

4. The amount of plutonium eliminated by the excreta for these cases studied over a 10,000 day post intake period, is 4 times greater than that predicted by the Langham power function model.

References:

La50 Langham W. H., Barrett S. H., Harris P. S., and Carter R. E., Distribution and Excretion of Plutonium Administered Intravenously to Man," Health Phys., 30, 1030.

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