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PLUTONIUM EXCRETION FOLLOWING CONTAMINATED
ACID BURNS AND PROMPT DTPA TREATMENTS

by

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RELEASED FOR ANNOUNCEMENT
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ABSTRACT

DTPA (diethylenetriaminepentaacetic acid) treatments removed 99.5 percent of the plutonium from an individual who suffered a contaminated nitric acid burn. The DTPA treatments were given promptly and continued for 27 consecutive days. A total of 210,000 d/m of plutonium was eliminated in the urine in the first 60 days after the accident.

This case is similar to an exposure which occurred at Rocky Flats a year previously. In both cases, a sum of two exponentials expresses the daily plutonium excretion in the urine over the first 60 days.

DESCRIPTION OF ACCIDENT AND TREATMENT

On March 25, 1965, an employee's left shoulder was contaminated with an acidified plutonium nitrate solution. The solution caused a second degree burn about 3 inches in diameter. No attempt was made to decontaminate the burn area. The burn healed without complication in about 3 weeks.

The Rocky Flats body counter indicated the presence of 0.3 ± 0.1 μc of plutonium in the burn area. This material was later found to be largely contained in the eschar.

The employee was given 1 gram of DTPA intravenously within 1 hour of the accident. A daily treatment was continued for 27 consecutive days. At that time the employee developed a skin rash. It is not known whether the DTPA treatments caused the rash, but it did clear up shortly after the treatments were stopped.

BIO-ASSAY RESULTS

The results of the plutonium analysis on blood, urine, and feces are shown in Table 1. The urine results exhibit a definite pattern when plotted on semilogarithmic paper (Figure 1). The pattern is a 2-fold exponential with half lives for elimination of approximately $\frac{1}{2}$ and $5\frac{1}{2}$ days.

The data points were fitted to a sum of two exponentials by a weighted least squares analysis. Days 6-60 were used to determine the longer component ($5\frac{1}{2}$ days). The contribution of this component was subtracted from Days 1-5 before the analysis was done for the shorter component ($\frac{1}{2}$ day). A comparison was made between this fit and those obtained from a single exponential function, a quadratic function, and a power function. The sum of two exponentials was found to be the best fit.

Table 1. Plutonium Bio-assay Results: Urine, Blood, and Feces (Man 3890)

<u>Days after Accident</u>	<u>Urine, d/m per 24 hrs.</u>	<u>Blood, d/m per 6 liters</u>	<u>Feces, d/m per 24 hrs.</u>	<u>Days after Accident</u>	<u>Urine, d/m per 24 hrs.</u>	<u>Blood, d/m per 6 liters</u>	<u>Feces, d/m per 24 hrs.</u>
1	196,300	550		31	17		
2	4,782	7,500	8.2	32	12		
3	1,546	360	137	33	8.5		
4	1,041		223	34	10		
5	685			35	5.7		
6	684		42	36	8.0		
7	387	270	17	37	2.7		
8	521	120		38	0.44		
9	543	1,800		39	0.26		
10	423		8.1	40	18		
11	363		9.2	41			
12	352	520		42			
13	540		22	43	5.3		
14	273		3	44	3.7		
15	177		3	45	29		
16	173	300		46	2.4		
17	87			47	3.2		
18	50			48	1.2		
19	121	940	6.4	49	4.1		
20	44		7.1	50	4.1		
21	100		2.7	51	4.2		
22	56	1,700	9.8	52	2.2		
23	63			53	2.3		
24	41			54	5.6		
25	17		4.3	55	6.0		
26	36		10	56	0.44		
27				57	0.60		
28	43			58	0.49		
29	33			59	1.68		
30	40			60	0.72

COMPARISON TO PREVIOUS CASE

This case is very similar to one that occurred in October, 1963. At that time an employee (2302) was sprayed with an acidified solution of PuCl_3 , PuCl_4 , and $\text{Pu}(\text{NO}_3)_4$. He sustained several small second degree acid burns. One-gram DTPA treatments were started promptly but were not continued on a daily basis. The plot of his urine results (Figure 2) is very much like the recent case. After 60 days, daily urine excretion rates had dropped to near pre-accident levels.

The urine excretion results showed half lives for elimination of approximately $\frac{3}{4}$ and 6 days.

EFFECTIVENESS OF DTPA TREATMENTS

When the first case (2302) was reported, the treatment was called "very successful." (1) Complete removal was not claimed because it was known that as much as 10 percent of the amount taken into the blood system could have been retained in the body. This conclusion is based on expected urine excretion rates without DTPA reported by Langham. (2)

Figure 2

Quantity of Plutonium in 24-Hour
Urine Samples (Man 2302)

Disintegrations Per Minute

10^5
 10^4
 10^3
 10^2
 10^1
 10^0
 10^{-1}

3-day half life

6-day half life

Days of
DTPA treatments

Days Following Accident

A total of 4,300 d/m was excreted in the urine following the DTPA treatments. If this 4,300 d/m represented 90 percent of the amount taken into the blood system, then 478 d/m was presumably unaffected by the DTPA and would have behaved as an exposure without treatment. Based on Langham's equation, the expected daily urine excretion rate in 60 days from this exposure (478 d/m) would be 0.41 d/m/24 hr. This man was excreting an average of 0.31 d/m/24 hr. before the accident and showed wide variations from the average on individual samples. It was not possible, therefore, to say whether or not there had been an addition of an amount of the order of 0.41 d/m/24 hr. in his urine.

In the more recent case (3890), a total of 210,000 d/m was excreted in the urine. If this represented 99.5 percent of the amount taken into the blood system, more than 1000 d/m remained in the body. One would expect excretion rates of 0.8 d/m/24 hr. in 60 days from the 1000 d/m. The average amount actually seen in 60 days was about 0.5 d/m/24 hr.

COMPARTMENT THEORY

It has been shown by Langham that when a soluble form of plutonium is injected into the bloodstream, the daily urine excretion rate decreases as a power function ($0.0023t^{-0.77}$). (2)

The power function is a convenient mathematical tool but has little biological implication. Chemical and biological reactions are often governed by first-order reactions, i.e., material is transferred in proportion to the amount present. When this is the case, an exponential function results. It is probable that the power function is an approximation to the sum of several exponential functions. A sum of several exponential functions would result from material being tied up in several compartments where the release from each compartment is first-order and independent of other compartments.

In the two cases presented here the daily urine excretion rates can be expressed as a sum of two exponentials. This would indicate that only two compartments are involved in the elimination and that the DTPA is responsible for preventing the plutonium from entering into other compartments.

SUMMARY

DTPA treatments were 99.5 percent effective in removing plutonium from an employee who was exposed via a contaminated acid burn. This is based on the assumption that the remaining 0.5 percent behaved as though it was unaffected by the DTPA treatments.

A sum of two exponentials was used to express the daily excretion of plutonium from this case and a similar previous case. Both cases were exposed to soluble plutonium and were given prompt DTPA treatments.

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