Biokinetics of soluble plutonium after wound injury treated with Ca-DTPA

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1 Introduction

The mission of the United States Transuranium and Uranium Registries (USTUR) is to study the uptake, translocation, retention and excretion (biokinetics), and tissue dosimetry of uranium, plutonium, americium, and other actinides in occupationally exposed volunteer Registrants (tissue donors). These individuals were mainly exposed to various types of plutonium material with inhalation and wound as primary routes of intake. The USTUR holds records of exposure history and bioassay measurements, as well as post-mortem tissue radiochemical analysis results for 19 individuals who had documented intakes of ^{239}Pu due to contaminated wounds. For 8 individuals, internal deposition resulted from a single wound injury, and three of them underwent decorporation therapy. In this study, USTUR Case 0303 was used to study biokinetics of soluble Pu after wound intake.

1.1 Case description

The USTUR whole-body donor (Case 0303) had been employed at a nuclear defence facility for 30 years. While working in a glove-box, he accidentally punctured his finger on a sharp object contaminated with plutonium nitrate. The contaminated tissue was surgically excised and found to contain approximately 2.33 kBq of ^{239}Pu while 0.78 kBq still remained in the finger. Worksite personnel estimated a systemic deposition of ^{239}Pu due to this accident as 85 Bq. This individual was medically treated with intravenous injections of Ca-DTPA. A total of 16 g Ca-DTPA was administered in 18 treatments during two months following the accident. Eighty-seven urine samples were collected and analysed over 14 years following the accident. This individual died 40 years post-intake at age 87.

2 Materials and Methods

Thirty-two soft tissue and 8 bone samples collected at autopsy were radiochemically analysed for ^{238}Pu, ^{239}Pu, and ^{241}Am. A complete description of the radiochemical analysis protocol has been published elsewhere [1]. To estimate the plutonium intake, late urine measurements (100 days after the last Ca-DTPA injection), which were unaffected by chelation, and post-mortem radiochemical analysis results were evaluated using the IMBA Professional Plus® software [2].

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3 Results and Discussion

Post-mortem radiochemical analysis of autopsy tissues indicated that forty years post-accident 12.2±0.3 Bq of ^{239}Pu was retained in the liver and 17.5±0.7 Bq in the skeleton. Activity measured in the skin and muscle tissue sample from the wound site was 0.26±0.01 Bq, while activity in the finger bone adjacent to the wound was measured as 1.09±0.03 Bq. Thus, a total of 1.35 Bq of ^{239}Pu was retained in the wound site.

Activity in the lungs including thoracic lymph nodes was estimated to be 0.14±0.01 Bq, two orders of magnitude lower than activity in the liver. This observation confirmed the assumption that soluble plutonium intake via wound injury was the major source of internal contamination for this individual.

Application of the NCRP 156 wound model [3] with default parameters for soluble strong material resulted in a credible fit to the data ($p > 0.05$) (Fig. 1). The residual intake was estimated to be 47.6 Bq and estimated committed effective dose was 24.1 mSv. By accounting for ~70.5 Bq of ^{239}Pu excreted during Ca-DTPA treatment, the total intake was estimated to be 118 Bq. Without Ca-DTPA treatment, this individual would have received a committed effective dose of 59.8 mSv. Chelation therapy reduced the radiation dose by a factor of 2.5.

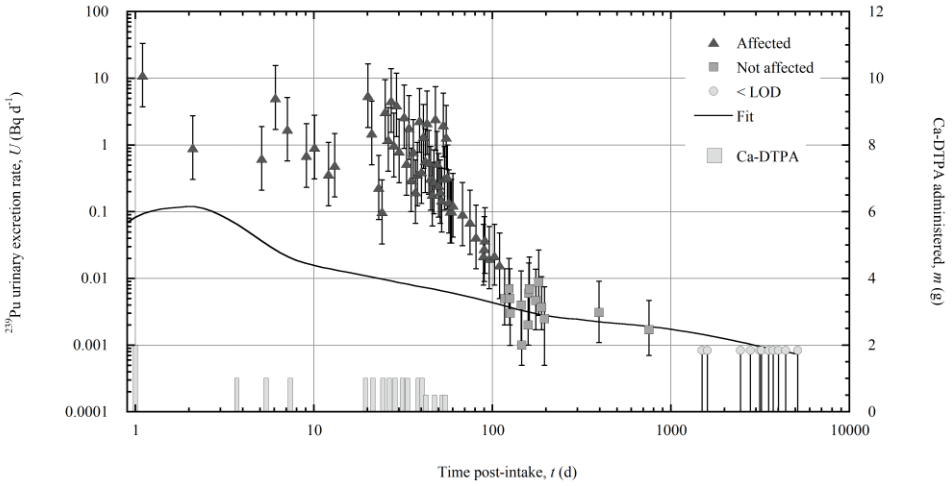

Fig. 1. ^{239}Pu daily urinary excretion and Ca-DTPA treatment data.

References

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