Dose assessment for workers involved in an internal contamination accident with Pu at JAEA's Oarai R&D Center

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1 Introduction

An internal contamination accident with plutonium (Pu) compounds occurred at a facility of the Oarai Research and Development Center of the Japan Atomic Energy Agency (JAEA) on June 6, 2017. The outlines of this accident are provided elsewhere [1]. On the day following the accident, the National Institues for Quantum and Radiological Sceinces and Technology(QST-NIRS) received the five workers who were involved in the accident and has continued direct and indirect measurements for internal dose assessments as well as treatments using chelating agents (Ca-DTPA, Zn-DTPA). The first dose assessment results of the five workers were reported on July 10, 2017; the highest dose estimate for the workers was found to be within 100–200 mSv as a committed effective dose (CED) [2]. This accident was the first internal contamination accident in which a decorporation therapy to remove inhaled Pu outside the body was performed in Japan. The decorporation therapy continued more than one month for three of the five workers. This paper describes highlights regarding the first dose assessment and some future developments, in particular for evaluating the dose reduction due to decorporation therapy.

2. The first dose assessment

The aim of the first dose assessment was to determine the workers' internal doses in a manner that would not result in an excessive overestimate, based on a reasonable interpretation of the measured results of faeces, urine samples, and the lungs. Regarding the

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lung counting with high-purity germanium (HPGe) detector arrays, americium-241 (^{241}Am) was detected from two of the five workers. The effective size of the inhaled Pu aerosols was estimated from the ^{241}Am activity ratio of the early faecal excretion (collected for the first 5 days after intake) to the residual lung deposition (Figure 1) [3]. The size determined was 5 μm in Activity Median Aerodynamic Diameter (AMAD) for the worker with the highest dose (Worker A) and 1 μm in AMAD for the other four workers. These sizes have been designated as default values for occupational exposure [4]. The absorption type in the respiratory tract was estimated from the urine samples collected prior to the first decorporation therapy using Ca-DTPA (calcium diethylentriamene pentaacetate) that was performed about half a dayafter the workers' intake at the JAEA-NCL. In a comparison with the predicted urinary excretion of Pu and ^{241}Am using the intake amounts calculated from the early faecal excretion, the results suggested a mixture of Type M and Type S materials (Figure 2). Type M (with higher dose coefficients for Pu) was thus selected to avoid underestimations of the doses.

3. Future development of the dose assessment

To evaluate dose reductions due to decorporation therapy, it is necessary to assess more accurate intake amounts as well as to develop a sophisticated model in which the impact of Ca/Zn-DTPA on the biokinetic behavior of Pu can be identified [5]. As described, the aerosol size of 5 μm in AMAD was determined for Worker A; however, larger aerosols are expected from the results (Figure 1). The early faecal excretion of ^{241}Am for Worker A was ~700 Bq, so that the predicted ^{241}Am lung deposition was ~100 Bq assuming 5 μm, which is much larger than the worker's lung counting result (20 Bq). Figures 3 and 4 are the preliminary calculations to explain the dose reduction for Worker A. Figure 3 compares the observed and predicted Pu urinary excretion (Type M, Type S, and Mix) for Worker A, indicating that the difference between the observed and predicted values is related to the dose reduction. Here the predicted values were obtained assuming the aerosol size of 15 μm, and those for Mix were obtained by adjusting the ratio of Types M and S to match the observed urinary excretion prior to the first decorporation therapy. Figure 4 shows the predicted residual Pu activity of blood, liver, bone and lungs for Mix without the effects of Ca/Zn-DTPA and indicates that the efficacy of Ca/Zn-DTPA at later days is very limited. However, a temporal increase in urinary excretion was observed in the urinary data obtained several months after the workers' intake, suggesting that the absorption parameters in the respiratory tract should be modified. Further analyses will be presented at the conference.

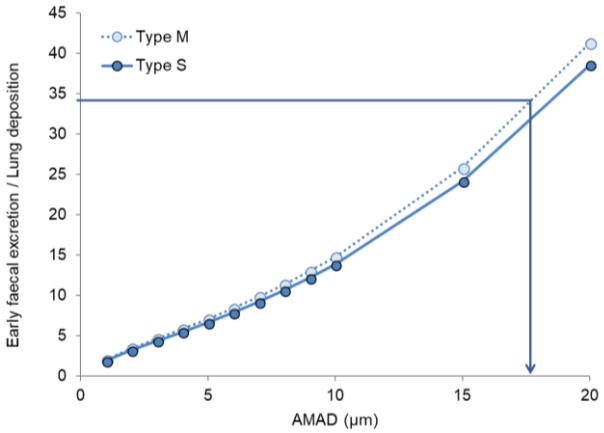

Figure 1. Estimation of the effective size of inhaled aerosols.

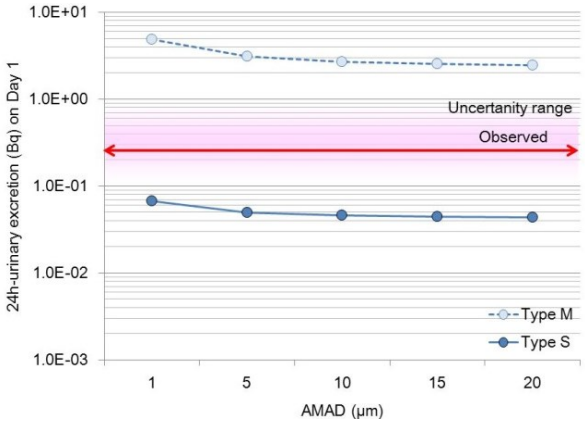

Figure 2. Estimation of the absorption type.

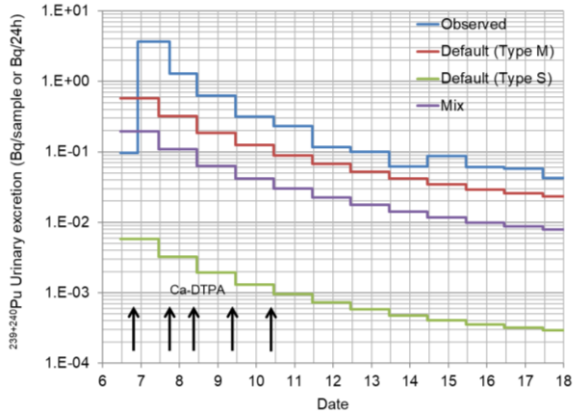

Figure 3. Comparison of the observed and predicted Pu urinary excretions.

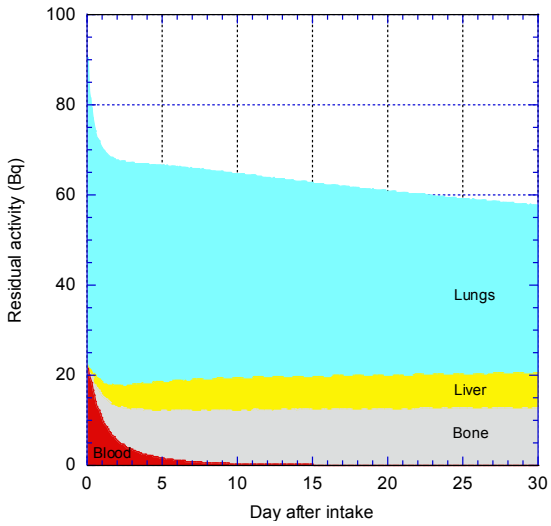

Figure 4. Predicted Pu residual activities in various parts of the body

References

1. Tatsuzaki et al. Radiat. Prot. Dosim (accepted)., Eur. Phys. J. E **14**, 7 (2004)
2. Japan Atomic Energy Agency, Report on contamination at the Plutonium Fuel Research Facility in the Oarai Research and Development Center (The third report) (in Japanese), Japan Atomic Energy Agency, 29 September (2017). https://www.jaea.go.jp/02/press2017/p17092902/ (accessed 2018-5-14)
3. IDEAS General Guidelines. General Guidelines for the Estimation of Committed Effective Dose from Incorporation Monitoring Data. FZKA 7243 (2006). http://www.bologna.enea.it/Rapporti/General%20Guidelines-FZK-report.pdf (accessed 2018-5-14)
4. International Commission on Radiological Protection. Dose Coefficients for Intakes of Radionuclides by Workers. ICRP Publication 68 Ann. ICRP 24 (4), Pergamon Press (1994)
5. Tani et al., This conference