

USTUR Case Study on Accidental Exposure to Uranium Hexafluoride

Maia Avtandilashvili¹, Stacey L. McComish¹, and Sergei Y. Tolmachev¹

¹*United States Transuranium and Uranium Registries, College of Pharmacy, Washington State University, Richland, WA 99354, USA*

The International Commission on Radiological Protection (ICRP) Human Respiratory Tract Model [1] was applied to the bioassay and autopsy data from the US Transuranium and Uranium Registries' (USTUR) whole-body donor 1031 to evaluate the committed effective dose due to an accidental exposure to large quantities of airborne uranium hexafluoride (UF₆) [2]. Bioassay data obtained for this case included eight urine samples analyzed shortly after the accident, and three follow-up urine measurements approximately four decades later. Recently, post-mortem analysis of tissue samples collected at autopsy was performed using inductively coupled plasma mass spectrometry (ICP-MS). Uranium (^{234,235,238}U) concentrations and ²³⁵U/²³⁸U and ²³⁴U/²³⁸U isotopic ratios were determined for 31 samples including 7 bones, lungs, liver, brain, kidney, and other soft tissues. ICP-MS analysis of right lung including thoracic lymph nodes (LNTH) demonstrated a ²³⁵U/²³⁸U atomic ratio of 0.00856±0.00005 that indicated significant retention of inhaled uranium material (enriched uranium) in the respiratory tract several decades post-accident. This is not consistent with the ICRP default assumption of a rapid lung dissolution pattern (absorption type F) for this type of material [1]. Urinalysis data along with tissue analysis results were used to calculate the point estimates of intake and dose. Uranium activities in tissues were adjusted to account for chronic exposure to natural uranium due to dietary intake, as well as through inhalation of ambient air. Uranium deposition in tissues that would have resulted from chronic ingestion and inhalation exposure was estimated based on the reference intake rates for the general population [3]. In this evaluation, mixtures of uranium materials with different absorption types – F, M, and S [1] were tested. It was demonstrated that, although the inhaled material consisted of mostly soluble fraction adequately described by absorption type F, approximately 13% of the mixture exhibited the slow dissolution pattern consistent with type S material. No deposition of type M material was confirmed in this evaluation. Total intake was estimated to be about 80 mg of uranium. This is about a factor of 2 higher than the intake reported by Kathren and Moore [2] based on urine data only. Committed effective dose of 3 mSv was calculated based on the assumption that the isotopic composition measured in the thoracic region of the respiratory tract represents the inhaled material. Approximately 60% of the total effective dose was contributed by the lungs.

Reference

1. International Commission on Radiological Protection. Human respiratory tract model for radiological protection. Oxford: Pergamon Press; ICRP Publication 66; Ann ICRP 24(1-3); 1994.
2. Kathren RL, Moore RH. Acute accidental inhalation of U: a 38-year follow-up. Health Phys 51(5):609-619; 1986.
3. United Nations Scientific Committee on the Effects of Atomic Radiation. USCEAR 2000 Report to the General Assembly, with scientific annexes. Sources and effects of ionizing radiation. Volume I: Sources. Annex B: Exposures from natural radiation sources; 2000. Available at <http://www.unscear.org/docs/reports/annexb.pdf>