Developing a Methodology to Assess Human Lung Failure due to Uranium Dust Contamination - A Progress Report

F. Klimaschewski 1, A. Durakovic 2, G. Tromba 3, S. Pacile 4, D. Dreossi 3, C. Dullin 4

1. Uranium Medical Research Institute (UMRI), London, UNITED KINGDOM,
2. Uranium Medical Research Centre (UMRC), Washington, DC, USA,
3. Syrmep/Tomolab, Elettra Synchrotron Light Laboratory, Trieste, ITALY,
4. Dept. Diagnostic and Interventional Radiology, University Medical Centre Goettingen, GERMANY.


Introduction
The purpose of our work is the development of an adequate methodology to assess the contamination and failure of a human lung through the inhalational of depleted uranium dust. The internal contamination of humans with uranium dust through the inhalational pathway has not only occurred in industrial processing plants and mines but also on and near modern battlefields where uranium containing weapons have been used [1,2,3,4,5]. Perfecting this assessment method may allow future studies to create an image not only of embedded uranium particles but also visualize the effects on the lung cells, in particular the paratracheal lymph nodes where the concentration of alpha emitting uranium dust particles can lead to high local doses of ionizing radiation [6].

Methods and Materials
Step 1: The first step of our method was an X-ray micro tomography imaging study of the lung sample of a retired uranium contaminated Canadian worker of a uranium processing facility, who had undergone a successful lung transplant following a lung failure. A basic lung histology and histo-autoradiography images were not available. The first lung sample scan was performed to image a crosssection, a slice of 16 mm thickness.

Step 2: To refine the analysis a second micro-CT scan of a cylindrical section of the lung was taken at the Syrmep beamline of the Elettra Synchrotron Laboratory (Trieste, Italy) in free propagation phase contrast modality [7]. 3D rendering was used later to localize particles with 3D Fuji imaging software. MIP z-projections were a tool for fast reviewing the data.

Findings
The lung had collapsed and therefore its anatomy was difficult to analyze. The formalin could not be completely removed from the sample therefore the inner part of the sample showed airways still filled with formalin. This provided little contrast to identify finer anatomical details except for the surface of the lung samples' air filled alveoli. Nothing on the scans resembled the histology of lymph nodes. Numerous very bright spots, however, were scattered in the scan of the lung sample and may have been inclusions of metal particles such as uranium. The smallest inclusions found were much more frequent than the medium size ones and appeared in all scans in all locations as well as deep within the sample. Determining the exact material proved challenging. A more accurate quantitative study on distribution of these bright spots will be performed analyzing 3D volumes obtained from the micro-CT scans.

Conclusion
Different types of strongly absorbing particles within the lung could be detected. However, the 3D X-ray scans do not provide enough data to identify paratracheal lymph nodes and the particles as being uranium particles. There therefore was no logical conclusion about the extent of the uranium contamination. The chemical analysis of the particles based on the CT data remains challenging. Since the sample was not embedded it is unlikely that the histology can be done and the same region located for further CT scans. The work so far, however, provides the starting point of a search for a suitable methodology, therefore further work is warranted.

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References