Nucleation, Growth and Agglomeration of Renal Calculi in 1G and Microgravity

M. Kassemi*, Elise Griffin and I. Iskovitz
National Center for Space Exploration Research (NCSER)
NASA Glenn Research Center
Cleveland OH 44135

*Mohammad.Kassemi@nasa.gov

Renal stone disease is not only a concern on earth but can conceivably pose as a serious risk to the astronauts’ health and safety in Space. In this presentation, a Population Balance Equation (PBE) model of the nephron as a continuous crystallizer is presented to assess the risks of renal stone development for the astronauts during space travel. The model includes the effects of nucleation, growth and agglomeration on the renal stone size distributions in the nephron. Furthermore, the PBE model is coupled to a Computational Fluid Dynamics model for flow of urine and transport of Calcium and Oxalate in the nephron. Simulations using the coupled PBE-CFD model are used to parametrically isolate the effects of growth and agglomeration and to predict the impact of gravity on the stone size distributions. Results clearly indicate that agglomeration is the primary mode of size enhancement in both 1g and microgravity. Preliminary numerical simulations seem to further indicate that there will be an increased number of smaller stones developed in microgravity that will likely pass through the nephron in the absence of wall adhesion. However, upon reentry to a gravitational field the renal calculi can lag behind the urinary flow in tubules that are adversely oriented with respect to the gravitational field and grow/agglomerate to considerably larger sizes.