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Determination of the Toxicity of a Lunar Dust Simulant on Human Alveolar Epithelial Cells and Macrophages in vitro

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Abstract : Background: Astronauts will set foot on the Moon later this decade, and are at high risk of lunar dust inhalation. Freshly-fractured lunar dust produces reactive oxygen species in solution, which are known to cause cellular damage and inflammation. Cytotoxicity and inflammatory mediator release was measured in pulmonary alveolar epithelial cells (cells that line the gas-exchange zone of the lung) exposed to a lunar dust simulant, LMS-1. It was hypothesised that freshly-fractured LMS-1 would result in increased cytotoxicity and inflammatory mediator release, owing to the angular morphology and high reactivity of fractured particles. Methods: A human alveolar epithelial type 1-like cell line (TT1) and a human macrophage-like cell line (THP-1) were exposed to 0-200µg/ml of unground, aged-ground, and freshly-ground LMS-1 (screened at <22µm). Cell viability, cytotoxicity, and inflammatory mediator release (IL-6, IL-8) were assessed using MMT, LDH, and ELISA assays, respectively. LMS-1 particles were characterised for their size, surface area, and morphology before and after grinding. Results: Exposure to LMS-1 particles did not result in overt cytotoxicity in either TT1 epithelial cells or THP-1 macrophage-like cells. A dose-dependent increase in IL-8 release was observed in TT1 cells, whereas THP-1 cell exposure, even at low particle concentrations, resulted in increased IL-8 release. Both cytotoxic and pro-inflammatory responses were most marked and significantly greater in TT1 and THP-1 cells exposed to freshly-fractured LMS-1. Discussion: LMS-1 is a novel lunar dust simulant; this is the first study to determine its toxicological effects on respiratory cells in vitro. An increased inflammatory response in TT1 and THP-1 cells exposed to ground LMS-1 suggests that low particle size, increased surface area, and angularity likely contribute to toxicity. Conclusions: Evenlow levels of exposure to LMS-1 could result in alveolar inflammation. This may have pathological consequences for astronauts exposed to lunar dust on future long-duration missions. Future research should test the effect of low-dose, intermittent lunar dust exposure on the respiratory system.

Keywords : lunar dust, LMS-1, lunar dust simulant, long-duration space travel, lunar dust toxicity
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