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PULMONARY TOXICITY STUDIES OF LUNAR DUST IN RODENTS

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ABSTRACT

NASA has been contemplating returning astronauts to the moon for long-duration habitation and research and using it as a stepping-stone to Mars. Other spacefaring nations are planning to send humans to the moon for the first time. The surface of the moon is covered by a layer of fine dust. Fine terrestrial dusts, if inhaled, are known to pose a health risk to humans. Some Apollo crews briefly exposed to moon dust that adhered to spacesuits and became airborne in the Lunar Module reported eye and throat irritation. The habitable area of any lunar landing vehicle or outpost would inevitably become contaminated with lunar dust. To assess the health risks of exposure of humans to airborne lunar dust, we evaluated the toxicity of Apollo 14 moon dust in animal lungs. Studies of the pulmonary toxicity of a dust are generally first done by intratracheal instillation (ITI) of aqueous suspensions of the test dust into the lungs of rodents. If a test dust is irritating or cytotoxic to the lungs, the alveolar macrophages, after phagocytizing the dust particles, will release cellular messengers to recruit white blood cells (WBCs) and to induce dilation of blood capillary walls to make them porous, allowing the WBCs to gain access to the alveolar space. The dilation of capillary walls also allows serum proteins and water entering the lung. Besides altering capillary integrity, a toxic dust can also directly kill the cells that come into contact with it or ingest it, after which the dead cells would release their contents, including lactate dehydrogenase (a common enzyme marker of cell death or tissue damage). In the treated animals, we lavaged the lungs 1 and 4 weeks after the dust instillation and measured the concentrations of these biomarkers of toxicity in the bronchioalveolar lavage fluids to determine the toxicity of the dust. To assess whether the inflammation and cellular injury observed in the biomarker study would lead to persistent or progressive histopathological changes, a similar study was conducted to microscopically examine rat lung tissue and the associated lymph nodes for lesions, including fibrosis, 1 or 3 months after the instillation. The results from this ITI study led us to select two concentrations (20 and 60 mg/m³) for an inhalation study, in which rats were exposed to lunar dust 6 h daily for 4 weeks (5d/wk). Similar biochemical and histopathological assessments were carried out in these rats 1 day or 1, 4, or 13 weeks after the dust exposure. Rats exposed to lunar dust by ITI or inhalation showed effects indicating that the dust is moderately toxic. The data will be useful to establish safe exposure limits for astronauts working in a lunar habitat and also help engineers designing dust mitigation systems for lunar vehicles and habitats.