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Size-dependent proinflammatory effects of ultrafine polystyrene particles: a role for surface area and oxidative stress in the enhanced activity of ultrafines.

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Abstract

Studies into the effects of ultrafine particles in the lung have shown adverse effects considered to be due in part to the particle size. Air pollution particles (PM(10)) are associated with exacerbations of respiratory disease and deaths from cardiovascular causes in epidemiological studies and the ultrafine fraction of PM(10) has been hypothesized to play an important role. The aim of the present study was to investigate proinflammatory responses to various sizes of polystyrene particles as a simple model of particles of varying size including ultrafine. In the animal model, we demonstrated that there was a significantly greater neutrophil influx into the rat lung after instillation of 64-nm polystyrene particles compared with 202- and 535-nm particles and this was mirrored in other parameters of lung inflammation, such as increased protein and lactate dehydrogenase in bronchoalveolar lavage. When surface area instilled was plotted against inflammation, these two variables were directly proportional and the line passed through zero. This suggests that surface area drives inflammation in the short term and that ultrafine particles cause a greater inflammatory response because of the greater surface area they possess. In vitro, we measured the changes in intracellular calcium concentration in mono mac 6 cells in view of the potential role of calcium as a signaling molecule. Calcium changes after particle exposure may be important in leading to proinflammatory gene expression such as

chemokines. We demonstrated that only ultrafine polystyrene particles induced a significant increase in cytosolic calcium ion concentration. Experiments using dichlorofluorescin diacetate demonstrated greater oxidant activity of the ultrafine particles, which may explain their activity in these assays. There were significant increases in IL-8 gene expression in A549 epithelial cells after treatment with the ultrafine particles but not particles of other sizes. These findings suggest that ultrafine particles composed of low-toxicity material such as polystyrene have proinflammatory activity as a consequence of their large surface area. This supports a role for such particles in the adverse health effects of PM(10).

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