Effects of ultrafine carbon particle inhalation on allergic inflammation of the lung

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Background: Epidemiologic studies show that exposure to particulate air pollution is associated with asthma exacerbation. Ultrafine particles (diameter <100 nm) may contribute to these adverse effects.
Objective: To investigate potential adjuvant activity of inhaled elemental carbon ultrafine particles (EC-UFPs) on allergic airway inflammation.
Methods: The effects of ultrafine particle inhalation on allergic airway inflammation was analyzed in ovalbumin-sensitized mice and nonsensitized controls. Particle exposure (526 μg/m^3, 24 hours) was performed 24, 96, or 168 hours before or 24 or 72 hours after ovalbumin aerosol challenge. Allergic inflammation was analyzed at different time points after allergen challenge by means of bronchoalveolar lavage cell count and cytokine/total protein assays, lung histology, and airway hyperresponsiveness.
Results: In sensitized mice, inhalation of ultrafine particles 24 hours before allergen challenge caused a significant increase of bronchoalveolar lavage inflammatory cell infiltrate, protein, IL-4, IL-5, and IL-13 compared with relevant controls. These adjuvant effects were dose- and time-dependent and were still present when particle exposure was performed 4 days before allergen challenge. The adjuvant effect of ultrafine particles was also documented by increased mucus production, peribronchiolar and perivascular inflammation, and enhanced airway hyperresponsiveness. In contrast, particle exposure in sensitized mice after allergen challenge caused only moderate effects, such as a delay of inflammatory infiltrate and a reduction of cytokines in bronchoalveolar lavage fluid.
Conclusion: Exposure to ultrafine carbon particles before allergen challenge exerts strong adjuvant effects on the manifestation of allergic airway inflammation. Allergen-sensitized individuals may therefore be more susceptible to detrimental health effects of ultrafine particles. (J Allergy Clin Immunol 2006;117:824-30.)

Key words: *Particulate matter, elemental carbon ultrafine particles, allergic inflammation*

Environmental and occupational respiratory disorders

Several epidemiologic and clinical studies have shown an association between increased ambient air particle concentration and adverse respiratory and cardiovascular health effects, leading to enhanced mortality rates as well as to exacerbations of respiratory morbidity.[1-5] Ultrafine particles (UFPs, less than 0.1 μm in aerodynamic diameter) may contribute to the health effects of particulate matter (PM) for several reasons. UFPs are characterized by a high number concentration, low mass concentration, and a big surface area.[6] Compared with larger particles, they have a higher deposition rate in the peripheral lung, can cross the pulmonary epithelium to reach the interstitium,[7] and have enhanced capability to produce reactive oxygen species.[8-10] UFP originate mainly from incomplete combustion processes by road traffic emission and industry. Although only few studies have measured the number concentration of UFPs in ambient air, there is some evidence that, over the last decades, the UFP number concentration is on the rise.[11]

Asthma is a disease characterized by periodic airflow limitation, airway inflammation, and airway hyperresponsiveness (AHR).[12] Evidence on the effects of particulate air pollution on asthma exacerbation and hospital admissions is increasing.[5,13-18] A panel study on subjects with asthma found that UFP number concentration correlated closely with alterations in lung function[19]; furthermore, variations in the concentration of fine particles (PM 2.5) and UFP correlated with use of asthma medications.[20] These studies suggest that people with allergic asthma are more susceptible to the short-term acute effects of fine and ultrafine particle exposures.[21] Solid experimental studies addressing this hypothesis, however, are still lacking.

Several studies in mice have analyzed the effects of fine particles on the allergic sensitization phase[22-28] and have demonstrated that PM influences cytokine production, enhances specific IgE response, and modulates immunoglobulin-isotype switching. In particular, carbon black, which resembles the carbonaceous core of diesel exhaust, has been shown to enhance allergic sensitization[24-26,28] and stimulate both T_H1 and T_H2 responses.[29]

In contrast, there are few experimental data available on the effects of fine particles and UFPs on the elicitation phase of the allergic response.[30-32] Elemental carbon (EC)-UFPs are relatively inert particles, yet they represent a major component of urban airborne PMs.[33] In the current

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