

Editorials

Air sampling in occupational asthma

Key words: Occupational asthma, air sampling, aeroallergens

Epidemiologic studies suggest that in addition to genetic and other factors of individual susceptibility, one determinant of the prevalence of occupational asthma is the level of exposure to a workplace sensitizer,¹⁻⁵ both for high-molecular-weight sensitizers, such as allergens in flour^{1,2} and animal allergens,³ and for low-molecular-weight sensitizers, such as in red cedar dust and diisocyanates.^{4,5} However, conclusions have often been based on relatively crude exposure assessments that in turn were based on estimates from the industrial processes or from area sampling.^{5,6}

Although such methods can be adequate for assessing nonparticulate exposures in epidemiologic studies, personal sampling gives a better estimate of individual exposure. Methods have been available for area sampling of aeroallergens for several years,⁷ and personal sampling of aeroallergens in the general breathing zone has become more common in occupational studies within the past 5 years.^{1-3,8} Even better should be measurement of actual inhaled amounts and particle sizes of particle-related inhaled aeroallergens combined with knowledge of nasal and lower airway deposition, which could then be related to individual respiratory responses.

The site of respiratory deposition of particles relates largely to their aerodynamic diameter,⁹ defined as the diameter of a unit density spherical particle having the same settling velocity as the actual particle. This term compensates for the fact that particle settling relates not only to actual size but also to shape and density. Particles of relatively large aerodynamic diameter— $>10\text{ }\mu\text{m}$ —are deposited mainly in the nose, pharynx, and upper airway; particles measuring 5 to $10\text{ }\mu\text{m}$ are deposited mainly in larger bronchi; and particles smaller than $5\text{ }\mu\text{m}$ are deposited mainly in smaller airways (generation 14 and over). Therefore, it is expected that aeroallergens that are carried on, or that are part of, larger aerodynamic particles—eg, pollen grains—would be relevant mainly to rhinitis, whereas those associated with smaller particles would be more relevant to asthma—eg, animal allergens.

Abbreviations used

IPM: Inhalable particulate mass fraction
NRL: Natural rubber latex
RPM: Respirable particulate mass fraction
TPM: Thoracic particulate mass fraction

Factors other than particle size and concentration also determine inhaled particle deposition. Rhinitis or anatomic nasal abnormalities (as well as exercise) can lead to mouth-breathing, with loss of the nasal filter, and thus to more lower airway deposition. Lower airway anatomic abnormalities, congenital or acquired, can also change lower airway particle deposition. Effects of airway narrowing, leading to altered airway deposition, and increased inspiratory flow rates, leading to more central airway deposition, have also been demonstrated in older studies of inhaled particles from metered dose inhalers.¹⁰ Similarly, subjects with airflow limitation and smokers have been shown to have greater lung deposition of fine particles ($1\text{ }\mu\text{m}$ in diameter).¹¹ Additional determining factors are (1) exercise, which in addition to producing mouth-breathing will increase minute ventilation and thus increase the total inhalation of particles, and (2) reduced exposure, particularly in industrial settings, resulting from the use of appropriate well-fitting masks and other respiratory protection.

Improved understanding of exposure-response relationships in occupational upper and lower respiratory allergy requires measurement of inhaled particulate aeroallergen exposures in a manner relevant to their site of action. Recently, the American Conference Of Governmental Hygienists, the International Standards Organization, and the European Standardization Committee agreed on collection efficiency criteria for sampling devices for 3 particulate fractions: the inhalable particulate mass fraction (IPM), for materials that are hazardous when deposited anywhere in the respiratory tract; the thoracic particulate mass fraction (TPM), for materials that are hazardous when deposited anywhere within the lung airways and the gas exchange region; and the respirable particulate mass fraction (RPM), for materials that are hazardous when deposited in the gas exchange region.¹² These criteria include 50% cutoff points of 100, 10, and $4\text{ }\mu\text{m}$, respectively, in aerodynamic diameter.

The IPM, collecting all of the larger aerodynamic diameter particles that are trapped in the nasal filter, is important for studies of allergic rhinitis. Personal sampling devices meeting the collection criteria have been evaluated¹³ and used in several workplace studies.¹⁻³ The TPM, collecting particles capable of penetrating beyond

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the larynx, is more relevant to asthma studies; commercial personal sampling devices for this fraction are now available.¹⁴ Some samplers also measure all 3 fractions simultaneously¹⁵; studies of these in occupational asthma would be interesting.

As reported in this issue of the Journal, a study by Poulos et al¹⁶ involved personal air sampling with the IOM device, which meets these collection criteria,¹³ to collect particles carrying a natural rubber latex (NRL) allergen, Hev b 1, generated from latex gloves. They also sampled with adhesive in a nasal sampler as well as with adhesive tape on surfaces of the hands, gloves, and workbenches. The extracted particles were stained with a monoclonal antibody for surface Hev b 1 allergen before counting and sizing of the positive particles through use of light microscopy. The investigators previously used this type of nasal sampler to assess domestic aeroallergen exposures but not to assess occupational allergens.

This method is an exciting step toward better understanding of aeroallergen exposures in the workplace. The potential advantage of nasal sampling is to determine the true personal inhaled allergen exposure (provided that the worker is not mouth-breathing and provided that the relatively short sampling time captures the appropriate work activities and exposure). The method appears to be relatively practical for use in an occupational setting.

However, a number of caveats need to be considered in interpreting this data. The first pertains to the efficiency of the nasal sampler. Poulos et al report that in their "in-series" model, using a standard air sampling device behind the nasal sampler, the efficiency of the nasal sampler for collecting particles was 71% at flow rates expected in the nose and was less at lower flows. Despite a significant correlation with the personal air sampling results in the occupational exposure, the "in-series" results also showed significant variability in 5 repeated in vitro tests, the efficiency ranging from slightly greater than 50% to greater than 80% at expected nasal flow rates. Therefore, further research might be needed to maximize efficiency and reduce variability for future nasal particle samplers.

A second limitation concerns the relevance of the findings to occupational asthma, given the particle sizes measured. The relatively high efficiency of the nasal and breathing zone samplers for particles of high mass median diameter, of relevance to rhinitis, nevertheless makes it difficult to assess the lower respiratory exposure without more information on levels of inhaled smaller particles, which are likely more relevant to asthma.

A further caveat pertaining to interpretation of the study involves the marker used for allergen exposure. The study by Poulos et al aimed to compare numbers of measurable particles carrying the NRL allergen Hev b 1; they did not attempt in this study to determine actual allergen concentrations. This would be useful in further studies, as would determination of relationships between the size of the particles and the amount of allergen carried (as previously reported by this group for cockroach allergen, with a greater elution of allergen from larger particles, obtained from area samples¹⁷). Although larger

particles clearly have a greater absolute surface area per particle, smaller particles of cornstarch and other carriers of NRL allergens, with larger surface areas relative to their mass, might carry more allergen per unit of mass and might be more relevant to asthma.

Future studies would be of interest to assess (1) the issue of whether Hev b 1 is a true surrogate for NRL aeroallergen exposure or whether other NRL allergens might be more representative, (2) differences in particulate aeroallergen levels between powdered and nonpowdered NRL gloves and high- and low-protein NRL gloves, and (3) the reliability of the method to discriminate between the likely smaller differences between various latex glove types.

NRL aeroallergen assay offers a good occupational model for these determinations; if found to be valid, it could lend itself to other occupational aeroallergen exposures and enhance understanding of the pathogenesis of occupational airway disease. Such measurements could also be used clinically to assess "hidden" occupational allergen exposures—eg, for health care workers with NRL allergy who are moved to an apparent latex-free environment but have ongoing work-related respiratory symptoms.¹⁸ Exposure levels resulting from prophylactic workplace interventions, such as replacement of NRL gloves with low-protein, powder-free latex gloves,¹⁹ or from changes designed to reduce other aeroallergens could be further evaluated. Such measurements might also be useful in relating workplace respiratory aeroallergen exposure conditions to appropriate specific nasal or bronchial challenge conditions with aeroallergens in particulate form.²⁰

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