

Indoor Allergens Associated with Asthma Morbidity

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ABSTRACT

Recently, evidence has been presented that relates allergen exposure to asthma morbidity. First, the majority of asthmatic children are sensitized to common inhalant allergens, as determined by radioallergosorbent test and skin testing, implying that they are both exposed and genetically capable of producing high levels of immunoglobulin E antibody. Several series have shown that 50–80% of children with asthma have positive RAST or skin tests.^{1–3} The exception is asthmatic infants younger than 3 years, where less than 40% are sensitized,^{4–6} generally to food allergens and house dust mite.⁽⁶⁾ A second line of evidence is that acute asthma can be induced in sensitized asthmatics by the specific antigen in bronchoprovocation tests.⁽⁷⁾ Chronic asthma severity,^(1,2,8–10) and nonspecific airway hyperresponsiveness^(8–11) can be related to atopy; the frequency of attacks requiring emergency room treatment^(12–15) can also be shown to increase with environmental exposure to the specific antigen. Finally, avoidance of specific allergens can decrease chronic disease activity.^(16,17) This evidence suggests that it is clinically important to evaluate every child with asthma for the presence of allergy and to include allergy intervention measures in a treatment plan when indicated.

INTRODUCTION

SENSITIZATION OCCURS IN GENETICALLY SUSCEPTIBLE INDIVIDUALS who are exposed to inhaled or ingested allergens. IgE antibodies are produced by plasma cells which differentiate from B cells under the influence of antigen and specific regulatory T-helper cells.⁽¹⁸⁾ Because of this, persons with an appropriate atopic genetic background respond with prolonged IgE antibody to many allergens, which are ingested or inhaled. Atopic individuals may be identified clinically by a family or personal history of atopic diseases, such as infantile food allergy, eczema, or allergic rhinitis. Infants born to couples who are both atopic have an incidence of asthma, eczema and food allergy of almost 80%.⁽¹⁹⁾ The importance of a personal atopic history is demonstrated by a British study of a national cohort of children born in 1958. Children who had both infantile eczema and allergic rhinitis had a 15.1-fold greater risk of developing asthma in childhood.⁽²⁰⁾

Allergen sensitization is specific in that antibody only develops to environmental allergens to which the atopic person is exposed. Exposure must be also be sufficiently high in order to sensitize. The level of indoor aeroallergens that can be considered adequate to sensitize has been proposed for dust mite, cat, and cockroach. The data is strongest for dust mite, where the levels of 2 µg/gm in settled dust have been proposed as necessary for sensitization, or 10 µg/gm is associated with increased asthma morbidity.⁽²²⁾ Early exposure to concentrations of mite antigen of 2 µg/gm results in increased frequency of sensitization in childhood.^(14,15,22) Not only must exposure be sufficiently high to sensitize, but a few years exposure to these levels is required before sen-

sitization occurs. The most convincing evidence for the duration of exposure required is obtained from laboratory animal workers where several studies have found sensitization usually begins after 1–2 years exposure.⁽²³⁾

Once sensitization occurs, further exposure induces acute symptoms; in many individuals a period of more chronic inflammation and airway dysfunction is also induced by these exposures. Much of the disability in asthma is related to airway hyperresponsiveness, which causes individuals to respond with acute obstruction and asthma to many environmental triggers, such as exercise, cold air, and weather changes. It has been shown that airway hyperresponsiveness relates to the degree of IgE- (immunoglobulin E) mediated sensitization, whether measured by the intensity of an individual sensitivity,⁽⁸⁾ the number of positive skin tests, or by total serum IgE.^(2,9) Airway hyperresponsiveness in turn relates to chronic and acute asthma symptoms.⁽¹¹⁾ Thus it would seem that a cascade of steps is involved in the effect of environmental allergens on asthma morbidity: chronic allergen exposure sensitizes susceptible individuals and then induces chronic airway dysfunction which leads both to chronic obstruction and to airway hyperresponsiveness. This cascade is currently hypothetical, but evidence is accumulating to suggest that it is a common pathway to increased asthma morbidity.

In addition to the studies mentioned above, which relate bronchial hyperresponsiveness and chronic asthma symptoms to the presence of atopic background and IgE-mediated sensitivity in general, case-control studies have now been reported which relate these factors to acute asthma morbidity in a more direct way. At an Air Force base in northern California, epidemics of visits to the emergency room (ER) for acute asthma and hospitalizations coincide each year with an intense grass pollen season. In a case-control study, Pollart and her colleagues reported that 92% of asthmatic patients in this ER had IgE antibody for grass pollen, compared with 14% of control patients in the ER for other reasons.⁽¹²⁾ Case control studies from other emergency rooms have confirmed the importance of IgE sensitization as a risk factor for acute severe asthma attacks.^(13–15) One study,⁽¹⁴⁾ conducted in the Pediatric Emergency Room of Grady Memorial Hospital in Atlanta, Georgia found that 69% of children presenting with asthma had IgE antibodies to dust mite, cat, or cockroach, compared to 27% of control patients matched for age and gender. Household dust samples for cases and control subjects contained similar concentrations of house dust mite, cat, and cockroach allergens. However, 21 of 35 children (60%) presenting with asthma were sensitized and exposed to excessive concentration of these allergens compared to only 3 of 22 control children (14%), resulting in an odds ratio of 9.5 ($p < 0.001$). All of these studies reach the same conclusion: IgE sensitization to environmental allergens is an important and striking risk factor for acute severe asthma, but current exposure to those allergens is not.

Allergens are small proteins (molecular weight 10–30,000 daltons). Aeroallergens are either components of airborne vectors (as in the case of pollen grains or mite fecal particles) or are proteins in secretions which are adsorbed to airborne particles (as in the case of animal allergens). The important indoor allergens currently identified are house dust mite, cockroach, cats and dogs, and mold spores.

HOUSE DUST MITES

House dust mites *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus* are microscopic pteroglyph mites which infect home environments, especially bedding and carpets. They produce a potent allergen in fecal particles which are approximately the size of pollen grains and are found in large concentrations in settled dust collected from carpets and mattresses. Over half of asthmatics in urban populations are sensitized to these allergens.

COCKROACHES

Cockroach is another important indoor allergen. Cockroaches are members of the family *Blattidae*. Of the approximately 3500 members the most common in the United States are the German cockroach (*Blattella germanica*), the larger American Cockroach (*Periplaneta americana*), the brown, and the oriental cockroach. Several allergens have been identified, including *Bla* g I and II, and have been associated, not only with living organisms, but with the mix of body parts, feces, and other secretions called the “frass.” Thus allergen is plentiful in household dust specimens in homes with significant infestations as well as those without current infes-

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tation. Using immunoassays based on monoclonal antibodies to these allergens, measurable concentrations have been found in 80% or more of urban poor houses,^(3,14,15) and surveys of asthmatic populations in urban areas demonstrate 37% to 61% sensitization rates with skin test of radioallergosorbent test (RAST).⁽²⁾ Sensitized individuals have positive bronchoprovocation tests.⁽²⁰⁾

HOUSEHOLD PETS

Almost one third of homes have cats and dogs as household pets. Both animals produce potent allergenic proteins in their saliva and other secretions. The allergens are very widely distributed, apparently because the secretions dry on fur, skin, and clothing, then become airborne as dry vectors; these vectors are very sticky and adhere to clothing and are widely disseminated. As a result, the antigens can be found in surprisingly high concentrations in homes that never had pets, and even in institutions or new houses.⁽²⁴⁾

DISCUSSION

Given this rich exposure of allergens, it is not surprising that surveys of allergic and asthmatic populations with skin tests and RAST have found multiple sensitivities. Surveys in Wilmington and Atlanta found that 44% of asthmatics were sensitized to mite, 24% to cockroach, and 22% to cat.^(14,15)

In the multicenter epidemiologic study of asthma in minority children, the National Cooperative Inner City Asthma Study, the relationship of allergen exposure, IgE-mediated sensitivity and morbidity is being approached with a combination of careful evaluation by interview, skin test, and home visit. The interviews probe the frequency of asthma symptoms, the medications required to control those symptoms, and the frequency of school loss, emergency room visits, and hospitalizations. Skin tests are conducted to 12 allergens including mite (*D. pteronyssinus*, *D. farinae*), cockroach, two molds (alternaria, penicillium), cat, dog, mouse, rat, oak, grass, and ragweed pollen. In addition, home visits are conducted to inspect for potential problems such as mold and moisture, presence of cats and dogs, presence of rat and mouse infestations, and the existence of wall-to-wall carpeting. Environmental control resources, such as mattress and pillow covers, vacuum cleaners, laundry facilities and air conditioners are reviewed. At the end of the inspections, samples of settled dust are collected from the bedroom (carpet and bed), the television/living room (floor and furniture), and the kitchen with a hand-held vacuum.

This detailed information on symptoms, exposure to known indoor allergens and chronic asthma will allow the most comprehensive examination yet attempted of the importance of indoor allergens in asthma in inner-city children. After this extensive cross-sectional survey, an intervention is planned that will include home environmental interventions in addition to education and counseling concerning problems of adherence, access to medical care and appropriate treatment.

CONCLUSION

The home environmental interventions that are likely to be tested in the National Cooperative Inner-City Asthma Study will be adapted from those which have been suggested for the important indoor allergens, including the following:

1. Dust Mite: Because acaracides are modestly effective and the allergen exposure is worse in the bed, intervention will focus there. Mattress covers of vinyl or vinyl coated cloth should be fitted, along with similar covers for any pillows on the bed. Blankets, comforters, bedspreads, and sheets should be washed frequently. Washing in hot water (130°F) effectively kills mites in bedding but is not always practical, especially in inner-city homes. Washing with cooler temperatures effectively removes antigen but does not kill mites so the washing must be repeated every week or two.

In addition, usual cleaning with vacuum, if it is available, or with sweeping should continue. Area humidifiers, especially the popular portable cold steam vaporizers used in bedrooms to provide symptom-relief for asthmatic children, are a major contributor to local excessive moisture problems which can not only support

mite colonization but also mole growth. These vaporizers should not be used at all in the rooms where the child sleeps.

The only clinical trials of the effect of environmental controls on asthma have been conducted with mite allergens.^(16,17) In a representative trial, Ehnert and colleagues⁽¹⁶⁾ randomly assigned a group of asthmatic youngsters to one of three treatments: acaracides applied to the carpeting and bedding; mattress and pillow covers combined with acaracides; and placebo acaricide treatment of the floor. Only the group with mattress covers had a significant and sustained reduction in mite allergen, and only this group had a clear effect on airway hyperresponsiveness.

2. Pets: Cats and dogs should be removed from the home if the asthmatic child is sensitized to them. If the family is not willing to remove the pet, several compromise measures have been suggested, such as keeping the animal out of the child's bedroom, vacuuming frequently and washing bedding to remove allergen and even washing the cat itself. These measures are not likely to be nearly as effective since particles containing animal allergens are very adherent and are not significantly reduced for over 6 months even when the pet is totally removed from the house.⁽²⁴⁾

3. Cockroaches: Exterminating cockroaches requires a combination of insecticides (diazinone) and careful removal of open food debris and water. Both of these are not likely to affect roach eggs or the migration of insects from adjoining homes, so re-infestation is likely to occur and the insecticides and cleanup will have to be repeated. This ongoing process will obviously require education of families to be successful, and it must be said that none of the changes in living habits which are described as environmental controls can be successful unless the families of the asthmatic children are convinced that reeducation is necessary and that their efforts are important and effective.

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