

Air Filtration Devices in the Control of Indoor Allergens

Robert A. Wood, MD

Address

Johns Hopkins Hospital, 600 North Wolfe Street, CMSC 1102, Baltimore, MD 20287, USA.

E-mail: rwood@jhmi.edu

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There are a variety of air cleaning devices that have been developed for the control of indoor allergens and irritants. These include both portable, room-sized units, and central units for use with a home's heating and ventilation system. While air cleaners can help to reduce some allergens, such as those produced by cats and dogs, they are unlikely to work for most other indoor allergens. The use of air cleaners for the management of allergic disease is reviewed in this article, and specific recommendations for their use are provided.

Introduction

Air filtration units are commonly used by people who suffer from asthma and allergic rhinitis. However, while they may provide some benefit for some patients, the evidence to support their use is actually very limited. It is also important to recognize that they are likely to have a far greater effect on some allergens than on others.

A variety of air cleaning devices is available for use [1,2]. These include both portable room-sized units, and central units for use with a home's heating and ventilation system. Most of the portable units are based on one of two methods of filtration, either the electronic precipitator, or the high efficiency particulate air (HEPA) filter. Both of these varieties are capable of filtering small particles, and are therefore capable of removing airborne allergens. It is important that an appropriately sized unit be chosen for the room to be treated. With a properly sized unit, the air of a room will be filtered 10 to 15 times per hour.

Whole-house units can be used with any forced-air heating or cooling system. Some simply replace the usual filter with one that more efficiently removes small particles. These can cost as little as \$15. Other units include electrostatic precipitators that are installed in the central system. These are more costly and also require professional installation. While these central filters do remove allergens, they typically filter far less air than room-

sized units, and may therefore be less effective. There are actually very little data on these units' ability to reduce indoor allergens. Therefore, the bulk of this review focuses on room-sized units, which have undergone more detailed study.

Available Studies

When considering the available data on the use of air cleaners for the control of indoor allergens, it is appropriate to divide the studies into two groups. The first group of studies focuses on the effects of air cleaners on airborne allergens, but does not include any evaluation of clinical effect. The second group looks not just at allergen levels but, more importantly, attempts to study the clinical effects of air cleaners for patients with asthma and/or allergic rhinitis.

Studies of Allergen Removal

De Blay *et al.* [3] studied the effects of a HEPA room air cleaner using an experimental room that contained one cat. As shown in Table 1, they found that airborne cat allergen could be reduced by the air cleaner, and that the effects of the device were far greater when the room had no carpeting or when the carpeting was cleaned with a HEPA vacuum to help reduce reservoirs of allergen prior to sampling. When the air cleaner was used in an uncarpeted room, along with a HEPA vacuum cleaner, there was a 98% reduction in airborne cat allergen, compared with a reduction of 56% in an uncarpeted room in which the HEPA vacuum was not used. When carpeting was present, there was only a 7% reduction in airborne allergen with no vacuuming, compared with a 70% reduction with the addition of the HEPA vacuum.

Luczynska *et al.* [4] performed a similar study using actual homes with cats. In living rooms, a HEPA air cleaner reduced airborne Fel d 1 levels by 70% to 80%. In rooms frequented by the cats, which contained higher levels of cat allergen, the use of one and two HEPA cleaners only reduced the airborne allergen levels by 30%. However, after the carpet was thoroughly cleaned, a single air cleaner reduced the airborne Fel d 1 by 90%. Both of these studies demonstrate the effects that a large reservoir of cat allergen in carpeting may have on the ability of an air cleaner to reduce airborne allergen levels. This probably occurs in

Table 1. Effects of a HEPA air cleaner on airborne cat allergen

	Baseline	After 3 hours' air filtration	Using air cleaner and HEPA vacuum
Carpeted room	11.7	10.9 (7%)	3.5 (70%)
Uncarpeted room	12.6	5.8 (56%)	<0.2 (98%)

Numbers represent airborne cat allergen (Fel d 1) levels in nanograms per cubic meter. The numbers in parentheses represent the percent reduction in airborne Fel d 1. HEPA—high efficiency particulate air.

large part because the turbulence created by the air cleaner may disturb settled allergen, and thereby limit the efficacy of the air cleaner.

Two additional studies of HEPA air cleaners in homes were conducted in Manchester, UK. In the first, Custovic *et al.* [5] studied seven homes with cats by running an air cleaner for a total of 8 hours. Airborne Fel d 1 levels were reduced by 81% from baseline after 4 hours, and by 83% after 8 hours of air filtration. The second study evaluated the effects of HEPA air cleaners on dog allergen [6•]. Nine homes were studied. With a dog present in the room, airborne allergen was reduced by 75% after 8 hours of air filtration, while levels were reduced by 90% with no dog in the room.

Each of these studies demonstrates substantial reductions in airborne animal allergens with the use of HEPA air cleaners, especially when carpeting is removed or thoroughly cleaned. Two additional points should be noted, however. First, reductions in airborne allergen, in an experimental situation, do not necessarily translate to a guarantee of clinical benefit. Second, it is important to note that animal allergens have been most studied because their aerodynamic properties make them most likely to be affected by air cleaners. Because a substantial portion of the airborne cat and dog allergen is carried on small particles that can remain airborne for extended periods, an air cleaner has a greater change of reducing airborne allergen [4,5,7]. This is in contrast to dust mite and cockroach allergens, which are carried on larger particles that do not remain airborne, and are therefore less likely to be affected by air cleaners [8].

Studies on the Clinical Effects of Air Cleaners

A number of studies have evaluated the effects of air cleaners on allergic disease, including both asthma and allergic rhinitis. Both dust-mite and animal-allergic patients have been studied. While these studies provide some useful information, many are limited by small sample size, inadequate blinding, and/or a failure to measure airborne allergens.

Reisman *et al.* [9] studied the use of HEPA air cleaners in the homes of patients with asthma and allergic rhinitis who were allergic to house dust or house dust mites. The study was conducted over 8 weeks, which included 4 weeks using an active filter, and 4 weeks using a placebo filter. No allergens were measured, but an assessment of airborne

particulates revealed a mean 70% reduction in particulate matter ($\geq 0.3 \mu\text{m}$) when using the active filter. Overall symptom scores were not reduced, but a sub-analysis of the last 2 weeks of each study period did reveal a modest but statistically significant reduction in symptoms with the use of the active filter compared with the placebo filter.

Van der Heide *et al.* [10] also studied the effects of air cleaners on patients with asthma and dust-mite sensitivity. Forty-five patients were studied in a double-blind fashion for 6 months by randomly assigning them to one of three treatment groups: one group had active air cleaners in the bedroom and living room, a second had active air cleaners plus allergy-proof mattress covers, and the third had allergy-proof covers and placebo air cleaners. Airborne allergen levels were not measured, but the filters were assessed for allergen content at the completion of the study, demonstrating high levels of cat and dust mite allergen on the active filters. Significant improvements in bronchial reactivity upon histamine challenge were detected only in the group that had both active air cleaners and allergy-proof covers, suggesting that this combination was more effective than either measure by itself.

Two other studies of air cleaners for dust mite allergy failed to show any significant benefit [11,12]. In addition to these, three additional studies utilized a laminar flow filtration device that was attached to the patients' beds [13–15]. This approach might provide more effective allergen removal in the patient's personal breathing zone as compared with a room air cleaner, which could be especially useful for dust mite allergy and the high-level exposure that may occur when lying in bed. Each of these studies did report improvement in symptoms or reduced medication use. However, while these results are clearly of interest as a demonstration of the benefits of allergen avoidance measures, these devices are not routinely available or practical for routine use.

Two studies have been published on the use of air cleaners for patients with mold allergy, both focusing on allergic rhinitis rather than asthma [16,17]. Both studies reported a reduction in symptoms and medication use. However, both of these were unblinded studies with no placebo controls. When considering the significant placebo effect that might occur with the use of an air cleaner, it is difficult or impossible to make any conclusions based on these studies.

The final two clinical studies focused on patients with animal allergy. We studied 35 adults with cat allergy who

Table 2. The effects of a HEPA air cleaner on cat allergy

	Active filter group		Placebo filter group		P value
	Baseline	Month 3	Baseline	Month 3	
Morning nasal symptoms	1.40±0.60	0.91±0.61	1.22±0.63	0.88±0.64	0.769
Morning chest symptoms	0.82±0.61	0.29±0.38	0.86±0.63	0.55±0.60	0.388
Morning peak flow rates (L/min)	429±120	458±133	457±118	503±111	0.424
PRN nasal medications (doses/day)	0.69±0.78	0.48±0.57	0.42±0.58	0.66±1.13	0.65
PRN chest medications (doses/day)	0.89±1.47	0.52±1.03	1.74±1.82	1.79±1.77	0.045
Airborne Fel d I level (ng/m ³)	3.0±1.1	1.7±1.7	2.6±1.2	2.8±1.8	0.045

HEPA—high efficiency particulate air; PRN—as required.

owned one or more cats [18•]. All patients were given mattress and pillow encasements, and instructed to keep the cats out of their bedrooms. Patients were randomly assigned to receive either an active or a placebo HEPA air cleaner. While airborne cat allergen was significantly reduced with the use of an active air cleaner, there was no improvement in any clinical endpoint, including nasal or chest symptom scores, medication use, peak flow rates, pulmonary function tests, or airway reactivity (Table 2). Based on these results, we concluded that a single air cleaner is not capable of sufficiently reducing cat allergen exposure to help control symptoms in highly allergic patients. However, we did admit that the study was not perfect; if it could be done again, we would extend the study for at least 6 months, and try to have all patients remove carpeting from their bedroom.

In the most recent study to be published on this topic, van der Heide *et al.* [19•] evaluated the effects of air cleaners in the homes of asthmatic children who lived with one or more cats or dogs to which they were allergic. The air cleaners were placed in the bedrooms and living rooms and the children were studied using a double-blind, placebo-controlled, crossover design of active and placebo air cleaners for a total of 6 months. Allergen levels in settled dust did not change and airborne allergen levels were not measured, although researchers did detect high allergen levels on the active filters at the completion of the study. Symptom scores and medication use did not change, but a significant decrease in airway reactivity as assessed adenosine challenge was found with treatment with the active filters. There was also a modest improvement in peak flow amplitude. The authors concluded that the use of air cleaners in the homes of these children with pet allergy resulted in significant improvements in their disease.

Conclusions

At the present time, the role of air cleaners for the control of indoor allergens is not well defined. They appear to have relatively little value in the control of dust mite allergens, and there have been no placebo-controlled trials of air

cleaners for mold allergy. They make the most sense for animal allergy in view of the particle size distribution of these allergens. However, the studies in this area are far from definitive. Further study in all of these areas is clearly needed. In the interim, however, it is still reasonable to recommend air cleaners to allergic pet owners who refuse to remove the offending pets from their homes. This should in no way be considered an option for removing the animal from the home for the highly allergic patient, but it may help for the patient with less severe allergy, especially if they take other measures to help reduce allergen. These should include keeping the pet out of the bedroom, using mattress and pillow encasements, and removal of carpeting, especially in the bedroom. Based on the van der Heide study [19•], it may also be more effective if air cleaners are placed in both the bedroom and the family room.

References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:

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This study is important in that it is one of the few controlled trials of air cleaner use in pediatric asthma. It is also the study that provides the most convincing data on the potential benefits of air cleaners.