



Does Air Filtration Work for Cat Allergen Exposure?

Alina Gherasim¹ · Frédéric de Blay^{1,2,3}

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Abstract

Purpose of Review The goal of this review is to compress all important information and results of the research in reducing cat allergen exposure using air filtration. Fel d 1 is the major allergen responsible for IgE responses in 90 to 95% of patients with cat allergy.

Recent Findings Reduction of cat allergen in indoor air with different air filtration systems and portable devices has been demonstrated in the majority of the studies. Recently, early and late asthmatic responses were significantly reduced using portable HEPA air cleaners in an environmental exposure chamber.

Summary This review provides a comprehensive overview of the current state of airborne Fel d 1 air filtration targeting the most efficient devices in cat allergen reduction. Novel emerging HEPA filters are targeting reduction of cat indoor asthma trigger so patient can benefit from efficient solution.

Keywords Cat allergen · Air cleaners · Indoor exposure control · Air filtration

Introduction

Indoor environmental allergen exposures control relies different strategies for avoidance measures, including air filtration. These methods may prevent sensitization, disease progression or triggering of symptoms and are defined by “methods to reduce occupant exposure to a contaminant in the environment, when the source of the exposure is likely to persist, such as with pet or dog in situ” [1]. Usually, exposure reduction includes modification of the dwellers’ habits but also can require removal of the triggers or reducing the source of allergen contamination in the environment that lead to the development or persistence of clinical manifestations of allergic diseases. An atopic patient who is sensitized to cat should not live with a pet. Cats (*Felis domesticus*) are the most popular pets in the world [2], and their close contact with humans, especially with those cat-sensitized,

increase the risk to develop diseases most commonly associated with cat allergens: allergic rhinoconjunctivitis and asthma [3, 4]. In such case, source control involves the complete removal of the furry animal. As cat owners consider them part of the family, allergist’ guidelines-based recommendations to get rid of the favorite pet in order to avoid cat allergen exposure are often unlikely to be followed. For this reason, control methods are needed to better manage cat exposure so that the pet can remain. Here, air filters should be helpful in reducing exposure to airborne pet allergen particles [1].

Prevalence of Cat Sensitization and Allergy

In Europe, it is estimated that the prevalence of cat sensitization varied from 15% in the South to 30% in Northern Europe [5–7]. In the USA, in children aged 1–5 years, 5% had specific IgE to cat and 12% of the adults. The overall prevalence of allergic sensitization did not vary across the USA [8]. In Asian countries, the sensitization varied from 12.2 in Sri Lanka [9] to 30% in Zhengzhou, a district of China [10]. From 2005 to 2014, the prevalence of allergic sensitization to pets increased from 16.5% to 28.5% in China, suggesting the importance of introducing more effective measures for its prevention and treatment [11]. The impact of early-life allergen exposure on sensitization to cat has been widely discussed [12]. However, recent paper suggested that exposure to cat in the first years of life increased

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✉ Alina Gherasim
alina.gherasim@alyatec.com

¹ ALYATEC® Environmental Exposure Chamber, 1 place de l’Hôpital, 67000 Strasbourg, France

² Chest Diseases Department, Strasbourg University Hospital, 1 place de l’Hôpital, 67000 Strasbourg, France

³ Federation of Translational Medicine EA 3070, University of Strasbourg, Strasbourg, France

the risk of sensitization with an OR 2.5 [13•]. A more recent study found a significant interaction between early-life cat allergen exposure and the FLG mutations on the development of cat sensitization during childhood [14•]. Also, it has been shown that sensitizations to Fel d 1 in childhood were significantly associated with symptoms to cat at age 16 years [15].

Exposure to Cat Allergen

The major cat allergen, Fel d 1, is the most common indoor allergen causing IgE-mediated allergic responses in 90 to 95% of patients with cat allergy and accounts for 60 to 90% of the total allergenic activity of cat extracts [16, 17]. Primarily produced in cat sebaceous glands and secreted into the skin and fur [18, 19], Fel d 1 is thought to be under hormonal control [20] and can vary from 1 to 10 for the same cat, not shedding airborne Fel d 1 at the same rate [21].

Recently, new approaches for reducing Fel d 1 allergen load takes advantage of the antibody-allergen interaction to neutralize Fel d 1 after its production by the cat but before it spreads to the environment. A recent pilot study has demonstrated the efficacy of a cat diet with an egg product ingredient containing anti-Fel d 1 IgY, resulting in significant decreases in active Fel d 1 in the cats' saliva [22].

In homes with cats, up to 50% of airborne Fel d 1 was found to be associated with particles greater than 10 µm in diameter, whereas around 23% was associated with inhaled particles smaller than 4.7 µm diameter. In addition, 60% of airborne Fel d 1 settles out within 30 min and 2 days of disturbance, leaving smaller particles that can remain airborne for up to 14 days or longer [23, 24]. It has been shown that the highest amount of Fel d 1 is found in households with cats and that airborne concentration increases in line with the number of cats kept in a home [25]. Airborne cat allergen can be dramatically reduced by a combination of washing the cat, reducing furnishings, vacuum cleaning and air filtration [26], but did not remain low 1 week later [27].

As cat allergens have shown to be carried for a significant part on small particles remaining airborne, the ability to filter cat allergen from the air depends on its aerodynamic diameters, size, and density, as well as its concentrations, aerosolization, airflow, and dilution rates [28]. Also, cat allergen could be found on different surfaces and clothing; source elimination is almost impossible [29]. In houses without a cat or classrooms with cat owners, airborne Fel d 1 could be measured [8, 30, 31]. Cat-sensitized patients are at higher risk to develop allergic rhino conjunctivitis [32] associated with allergic asthma [33].

Types of Air Filtration Systems

The main objective of air cleaning and filtration in the living environment, based on recommendation, especially for those

with allergic respiratory diseases having a cat at home, is to reduce disease progression, as add-on therapy [34•, 35]. The American Academy of Allergy, Asthma and Immunology Indoor Allergen Committee states that sufficient evidence indicates that air filtration reduces indoor cat airborne levels that may trigger disease progression, but often the result of previous prolonged exposures either in the home, other environments, or both will not abate within a few weeks or even months after the placement of an air-cleaning device or filter in the home environment [36••]. In this rostrum, air-cleaning products and devices for residential buildings are classified into 2 broad categories: whole-house filtration (WHF), which are filters or cleaners that are installed on the central HVAC system and free-standing portable room air cleaners (PRACs).

Environmental control practices (ECP) are a group of measures recommended to reduce exposure to indoor allergens or nonallergic triggers [37].

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standardized efficiency testing methods by measuring and counting particles across the filters. The results are divided in 3 different classes, expressing the particle size range, meaning the determination of "Minimum Efficiency Reporting Value" (MERV) from 1 to 12. The efficiency testing uses a challenge aerosol measured in 12 ranging with 90% filtration of particle size from 0.30 to 10.0 µm diameter [38]. Moreover, other attributes of the filter include a reasonable retention capacity, which must be sufficient to avoid its full load until maintenance, as well as the adequate air flow for ventilation.

WHF with HVAC Systems

They protect equipment and can reduce exposure to particulate matter. The WHF's goal is to heat, cool, and clean interior transported air before being recirculated back into the room. There are a wide range of performance filters proving the indoor air quality, divided into different groups:

- Panel filters
- Washable filters
- EACs (powered electronic filters)
- HEPA filters (high-efficiency particulate air filters)

Panel filters have been used for several decades and generally consist of inexpensive materials such as fiberglass or synthetic materials. The panel filters cannot filter small particles size due to their low MERV rating. Moreover, they could even worsen filtration by capturing and then dumping particles downstream. Changing filter every 3 months is highly recommended.

Washable panel filters are mainly used to filter above 10 microns of dust particles in the air. They are generally made of metal or woven nylon filament and depend on the natural electrostatic charge of the filter materials, which leads to a decrease in their effectiveness. Moreover, an inappropriate cleaning of the

filter increases the risk of mold and bacteria appearance. All of these considerations led this type of filters less convenient.

Powered electronic filters (EACs) called electrostatic precipitators, are highly efficient devices in which air is ionized in a high-voltage electric field with a low airflow resistance. The only inconvenient is that they tend to quickly lose efficiency as the plates load and become covered with dust, therefore they need monthly cleaning.

HEPA stands for high efficiency particulate air filter that can trap tiny particles on 0.3 in order to earn the HEPA rating; they must do so with 99.97% efficiency. HEPA filters for HVAC systems require a more powerful blower on air handler to maintain airflow through the dense filtration media, resulting in higher maintenance costs.

Free-Standing Room Air Cleaners or Portable Air Cleaners

They are the most popular devices using HEPA-like filters. Portable room air cleaners are rated in accordance with the Association of Home and Appliance Manufacturers (AHAM) standards [39], calibrated to filter different ranges of particle size. The higher the number of particles, the faster the device delivering cleaned air [38].

Cat Allergen Reduction with HEPA Air Filters

Frequent vacuuming with a HEPA vacuum or standard vacuum with double-layered bags helps reduce cat allergen in carpets. Woodfolk and colleagues [40] studied the effectiveness of 4 groups of vacuum cleaners in controlling airborne cat allergen during vacuuming. Vacuum cleaners with double-thickness vacuum bags and HEPA filtration effectively retained cat allergen compared with the other models studied, which leaked allergen. When modified with an electrostatic filter, some models more effectively captured and retained allergen.

One of the consensus recommendations in avoidance of cat allergen triggers is vacuum cleaning intensively using either a HEPA vacuum or a standard vacuum cleaner with double-lined bags [1]. Gore et al. [41] suggested that even using some HEPA filters, cleaning can be inadequate, and moreover, vacuuming can increase one's personal exposure to cat allergen.

In a comparative study between two different types of vacuum cleaners on airborne Fel d 1 levels, a semi-stationary vacuum cleaner that conducts the air to the exterior through a valve in the wall significantly reduced amounts of airborne cat allergen than the traditional canister type vacuum cleaner (mean 2.1 ng/m³ air versus 5.2 ng/m³) [42].

One study described a significant reduction in the quantity of inhaled Fel d 1 when an air cleaner was used in the presence of a cat. The use of a HEPA air cleaner in the living room reduced airborne Fel d 1 levels by 70–80% in seven homes with a cat, compared with 30% in apartments containing higher levels of

cat allergen. So, it appeared that the use of HEPA air cleaner was efficient to reduce airborne cat allergen [43].

Using forced air ventilation filters with MERV 12 or higher effectively reduced indoor airborne cat allergen by more than 50% [44].

Clinical Efficacy

Contradictory results have been reported in previous clinical studies of cat-allergic patients using HEPA air cleaners.

Among asthmatic patients sensitized to cat and dog, Francis et al [45] found that the use of portable HEPA air filters reduced a combined asthma outcome (comprising at least a doubling dose in histamine hyperreactivity or a reduction treatment mounting of one-step change) in 10 of 15 patients at 12 months intervention as compared to placebo. No significant differences were found between the active and control group in terms of changes in measures of lung function, reservoir pet allergen, and airborne cat allergen.

The efficacy of HEPA filters with air cleaners was found in a double-blind placebo-controlled study with 20 asthmatic children allergic to cat and dog. After 3-month intervention, they found a significant decrease in nonspecific hyperresponsiveness with a 1.2 doubling dose increase of PC adenosine. Also, PEF amplitude decreased significantly. No significant differences were seen in airborne Fel d 1 concentrations [46].

In contrast, among 35 adult cat-allergic patients, studied during 3 months, a significant decrease in airborne Fel d 1 was found. However, no clinical improvement was observed when using HEPA air cleaners (i.e., with regard to nasal symptoms, PEF and chest symptoms, sleep disturbance, and rescue medication use measured 3 times a day, every month) [47].

In a double-blind randomized controlled study, using HEPA filters during 12 months in houses in 36 asthmatic children allergic to cat or/and dog with pet in situ did not significantly decreased cat allergen concentrations in dust samples. Clinical efficacy was assessed with pulmonary function, cold air challenge. Serum eosinophil cationic protein levels were also measured. After 6 and 12 months, there was no significant change in delta FEV₁ after cold air challenge or in the use of medication and serum eosinophil cationic protein levels. There was a trend of improvement in bronchial hyperresponsiveness in active air cleaners group [48].

All these limited studies were field studies, and the efficacy of air cleaners has not been assessed by measuring their effect on early and late asthmatic reactions.

This was performed by using a new generation of HEPA filter (H13) in cat-asthmatic patients during tight controlled cat allergen exposures in an environmental exposure chamber (EEC) [49•]. Fel d 1 airborne allergen concentration dramatically decreased from 36.3 to 4.70 ng/m³ with an interassay CV of 35% (*n* = 4). Meanwhile, during the PCB air cleaner exposure, the mean

airborne Fel d 1 concentration did not decrease and stayed at 37.10 ng/m³ with an interassay CV of 8.20%. In this randomized, double-blind placebo-controlled clinical study, for the first time, a significant decrease of cat airborne allergen was associated with an improvement of early and late asthmatic reaction. Indeed, the frequency of early and late asthmatic responses decreased by 60% compared with sham air cleaners. The incidence of having an early asthmatic response was expressed by Cox model with a hazard ratio of 0.10 ($p = .0019$) during a 2-h exposure.

Conclusion

This comprehensive review of literature strongly sustains that cat allergen is still a very good model to assess the efficacy of air filtration devices, since a large proportion of airborne Fel d 1 is carried in particles less than 5 μm , being the most difficult aeroallergen to be filtered. Based on new and old publications, there is sufficient evidence that air filtration does reduce indoor cat allergen levels. For households with forced air HVAC systems, regular maintenance schedules and the use of high-efficiency disposable filters appear to be the best choices. As far as optimal choice of cleaning devices, initial cost and ease of regular maintenance should be considered. Portable room air cleaners with new generation HEPA filters appear to be beneficial for airborne Fel d 1 air filtration. Their clinical effect of cat-allergic asthma has been demonstrated experimentally. However, future longitudinal double-blind placebo-controlled in field studies are needed to assess and sustain the efficacy of such devices. However, the use of EEC to assess the clinical efficacy of such devices before performing a very expensive field study appears to be of interest.

Compliance with Ethics Guidelines

Conflict of Interest Dr. DeBlay reports a Board Membership on Stallergenes-Greer SVB, ALK, Novartis, Grants from Aimmune, Chiesi, Stallergenes Greer. Dr. Gherasim declares no conflicts of interest relevant to this manuscript.

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