



How Do Storms Affect Asthma?

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Abstract

Purpose of Review There are observations in various geographical areas that thunderstorms occurring during pollen seasons can induce severe asthma attacks in pollinosis patients.

Recent Findings An accredited hypothesis explaining the association between thunderstorms and asthma suggests that storms can concentrate pollen grains at ground level, which may then release allergenic particles of respirable size in the atmosphere after their imbibition of water and rupture by osmotic shock. During the first 20–30 min of a thunderstorm, patients affected by pollen allergy may inhale a high quantity of the allergenic material that is dispersed into the atmosphere as a bioaerosol of allergenic particles, which can induce asthmatic reactions, often severe. Subjects without asthma symptoms, but affected by seasonal rhinitis can also experience an asthma attack. A key message is that all subjects affected by pollen allergy should be alerted to the danger of being outdoors during a thunderstorm in the pollen season, as such events may be an important cause of severe asthma exacerbations. In light of these observations, it is useful to predict thunderstorms and thus minimize thunderstorm-related events. Patients with respiratory allergy induced by pollens and molds need to be informed about a correct therapeutic approach of bronchial asthma by inhalation, including the use of bronchodilators and inhaled corticosteroids.

Summary The purpose of this review is to focalize epidemiological, etiopathogenetic, and clinical aspects of thunderstorm-related asthma.

Keywords Climate change and allergy · Thunderstorm asthma · Global warming and allergy · Storms and respiratory allergy in pollen seasons · Pollinosis · Allergenic pollens and asthma attacks · Aeroallergens · Acute asthma exacerbations

Introduction

Associations between thunderstorms and asthma morbidity have been identified in multiple locations around the world and evidence exists that thunderstorms during the pollen season can be associated with allergic asthma epidemics in patients with pollen allergy [1, 2, 3–5, 6, 7–15]. There is also

clinical and etiopathogenetic evidence about the possibility that storms can act directly or indirectly on the pollens at ground level, inducing the release from their cytoplasm of airborne allergenic components of respirable size into the atmosphere as trigger factors of allergic rhinitis and asthma, most commonly in the first 20–30 min from the start of a thunderstorm during pollen seasons [1, 2, 6, 7–13, 16–23].

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Physicians and patients with pollen allergy should know the mechanisms involved in the release of allergens from airborne pollen grains during thunderstorms and the associated risk of asthma in with the goal of prevention [6•, 7–32].

Epidemics of Asthma Attacks Related to Storms in the World

There are descriptions in the literature of epidemics that have happened in several areas in the world [1•, 2•, 3–5, 6•, 7–22]. Among the epidemics of asthma attacks, the worst happened in Melbourne (Australia) on Monday, 21 November 2016 [1•, 3–5]. On 21 November 2016, Melbourne experienced the most devastating thunderstorm asthma epidemic of the medical literature, a very unusual weather occurrence with wind and torrential rain combined with a high pollen count, sending high quantity of pollen allergens across the city. Moreover, the storm brought a cool change to the city, with the temperature dropping from 35 °C at 5:30 pm to 23 °C at 6:40 pm of 21 November 2016 [3–5]. Hospitals in Melbourne were swamped with emergency patients affected by severe asthma attacks. Nine patients died and thousands of people (more than 8500 patients) suffered breathing problems following the storm; many of whom had never had an asthma attack before Monday 21 November night and Tuesday 22. Police and firefighters helped physicians and paramedics respond to thousands of calls for the problems for citizens. It caused many people, including those who did not have a history of asthma but did have a history of allergic rhinitis, to experience breathing difficulties: reports include several cases of near fatal asthma and nine deaths.

“Hospitals in Melbourne were swamped with emergency patients, while firefighters and police were called on to help paramedics respond to thousands of calls after the conditions caused breathing problems for inhabitants of Victoria (Melbourne).”

Other Epidemics of Asthma Attacks Related to Storms in the World

There are descriptions in the literature of thunderstorm-related asthma outbreaks in various cities throughout the world such as Birmingham (UK) [9], London (UK) [8, 15], Melbourne (Australia) [3–5], Wagga Wagga (Australia) [13], and Naples (Italy) [1•, 2•, 27], but there are also case reports in other cities [14, 25]. One of the first observations regarding thunderstorms and asthma outbreaks was provided by Packe and Ayres [9] at the East Birmingham Hospital on 6 and 7 July 1983. These

authors described a striking increase in the number of asthma emergency department visit admissions during the period of a thunderstorm. Over a period of 36 h, 26 asthma cases were treated in the emergency department, compared with a daily average of two or three cases in the days preceding the outbreak.

Another asthma outbreak, the largest before the event of 2016 in Australia, occurred in London in coinciding with a heavy thunderstorm on 24 June 1994, when a large increase was observed in the number of visits for asthma at the emergency departments of London and the southwest of England (UK) [8, 15]. Several patients had a prior history of seasonal rhinitis but not asthma. This London epidemic had a sudden onset on 24 June 1994; 640 patients with asthma or other airways diseases visited emergency departments over 30 h from 18, nearly 10 times the expected number. Over half (365) of the patients were aged 21 to 40 years. A history of hay fever was recorded in 403 patients; for 283 patients, this was the first known attack of asthma. History of chronic obstructive airways disease was recorded in 12 patients. In all, 104 patients were admitted (including 5 to an intensive care unit). Six hundred and four (604) patients with wheezing and shortness of breath were seen in several departments, compared with an expected number of 66.6 for that time of the year [8, 15]. These results confirmed an asthma epidemic, with almost 10 times the usual number of patients presenting during 30 h and an excess of 574 patients attributable to the epidemic. The outbreak was not restricted to the London area, although the number of patients presenting to emergency departments on the night of 24 June 1994 was greater in the Thames regions than in other regions in England. Moreover, not all affected patients visited the hospital. This epidemic was the largest outbreak ever recorded before the terrible event of Melbourne 2016.

Other asthma outbreaks during thunderstorms were described in Melbourne (Australia) [7], where two large asthma outbreaks coincided with thunderstorms, though they were less severe than the epidemic of 2016. These events were also followed by a rapid increase in hospital or general practitioner visits for asthma. Further asthma outbreaks occurred in Wagga Wagga (Australia) on 30 October 1997 [13]. In Wagga Wagga, 215 patients with asthma attended the local emergency department; 41 of whom required hospital admission. In Italy, there was an epidemic in Naples (Italy) on 4 June 2004 [1•, 2•, 31], when six adults and one child received emergency treatment. All patients showed allergic respiratory symptoms upon exposure to *Parietaria* pollen, but were not sensitized to grasses. *Parietaria* is an Urticaceae, belonging to the nettle family that is widespread in the southern regions of Italy with a spring and summer pollen season that is, in part, coexistent with that of grasses [10, 11, 32, 33].

Etiopathogenetic Aspects in Thunderstorm Asthma

The most prominent hypothesis for thunderstorm-related asthma is linked with bioaerosols and involves the role of rainwater in promoting the release of respirable particulate matter. The discovery of airborne allergen-carrying particles much smaller than pollen grains, such as those released by pollens during weather perturbations, particularly thunderstorm and rainfall, provided a possible explanation of mechanism of thunderstorm asthma [10, 31, 32].

Although some aspects remain to be understood about the relationship between asthma attacks and thunderstorms, reasonable evidence exists in favor of a causal link in patients suffering from pollen allergy. Climate change in recent years has been associated with the increased frequency of extreme weather events, such as heat waves, heavy rainfall, and thunderstorms, [1•, 2•]. Rainfall is usually known to remove pollen from the air, but this is not always this case. Studies have revealed that allergens leave the pollen surface almost instantly, usually within seconds, upon contact with water [2•, 10]. Demonstrations have shown that changes in the weather such as rain or humidity may promote hydration of pollen grains and sometimes also their fragmentation, releasing allergenic biological aerosols into the atmosphere [2•, 32].

Intact pollen grains can penetrate the upper respiratory tract, but because of their large size, the diameter is always greater than 10 µm; the grains rarely reach the lower respiratory tract. However, asthma due to pollen exposure is not infrequent [2•, 6•, 10]. Indeed, the existence of allergen-carrying airborne particles much smaller than pollen grains (paucimicronic particles) can explain bronchial symptoms affecting subjects during storms in pollen seasons [6•, 10, 32]. Due to their size, these paucimicronic particles can penetrate deeply into the airways thus inducing asthma in sensitized atopic subjects.

Thunderstorms can concentrate ground-level pollen grains that are able to release allergenic particles of respirable size into the atmosphere after their imbibition and frequently rupture by osmotic shock [2•, 31]. The content of these pollen grains include inhalable allergen-carrying cytoplasmic granules (< 5 µm) or other paucimicronic components. Such small particles may be inhaled, reaching the distal lower airways and inducing bronchial inflammation and asthma in subjects with pollen allergy [2•, 6•, 24].

Consequently, during the first phase of a thunderstorm, pollen-allergic individuals may inhale a high concentration of dispersed allergenic material, which can induce asthmatic reactions, some of which are severe requiring visits to the emergency department [1•, 2•, 34]. Fortunately, despite the postulated association between thunderstorms and asthma, this climatic phenomenon does not seem to be responsible for a large annual number of exacerbations. Nevertheless, it

is important to determine the mechanisms involved in the release of allergens from pollens during thunderstorms so that patients with pollinosis (including those affected only by seasonal rhinitis) can receive information about the risk of an asthma attack [2•, 6•, 31, 35] (Table 1).

Conclusions

Thunderstorm-associated asthma is a dramatic example of the allergenic potential of pollen and fungal antigens. Pollen-allergic and mold-allergic patients who encounter the allergenic cloud are more susceptible to experience an asthma attack. Patients allergic to pollen who are in the path of the thunderstorm outflow are likely to inhale airborne pollen allergens and to experience an airway asthmatic response [1•, 2•, 27]. Relapse is also possible in some patients [35, 36]. The frequency of storms has recently increased in some geographical areas, particularly in temperate and subtropical areas [2•, 31, 35].

Patients affected by pollen allergy should be informed about a possible risk of asthma attack and relapse at the beginning of a thunderstorm during pollen season. Patients with a high degree of pollen allergy should consider staying indoors with closed windows if a storm is approaching during the pollen season [1•, 2•, 27, 35]. The same strategy has to be applied to mold-allergic patients for whom evidence on the relationship and on possibilities of prevention is less.

Table 1 Characteristics (environment and concerning allergic patients) of epidemics of thunderstorm-associated asthma in the world

- There is a link between storms and asthma epidemics in patients with pollen allergy during pollen seasons with appearance of symptoms during the first 20–30 min of a storm.
- Thunderstorm-related epidemics are limited to late spring and summer (in Europe, USA, and Canada from April to end of June and in Australia from October to December), when pollen and/or mold counts are high.
- There is no description in the literature of high concentrations of air pollution before and during thunderstorms.
- It is possible the role of sudden cold and/or electric charges as contributor trigger factors of asthma attack in allergic subjects.
- Individuals with allergic rhinitis alone and no previous asthma history can experience bronchoconstriction, sometimes severe, during thunderstorms.
- Subjects with pollen allergy need be informed about a possible risk of an asthma attack at the beginning of a thunderstorm during pollen season.
- Individuals who experience rhinitis and asthma during a storm are not usually taking suitable anti-inflammatory treatment. To prevent these symptoms, it is important to have a correct antiasthma treatment by using bronchodilators and corticosteroids by inhalation at increasing dosage if there is a need.
- There are no descriptions of allergic symptoms in individuals with allergy to pollens and molds but who are indoors with the window closed during a storm.

Even though thunderstorms can induce severe asthma attacks or exacerbations, fortunately, they are neither frequent nor responsible for a high amount of disease exacerbation [1•, 2•, 6•, 35]. This constitutes a major concern nowadays as the possibility of thunderstorm-associated asthma outbreaks have become of dramatic actuality due to the “highly likely” increase in frequency of heavy precipitation events, including thunderstorms, in the context of the climate change scenarios for the future decades [6•, 30, 35].

The increased concentration of allergenic pollen in general is now a public health problem [6•, 31, 35] and influences the degree of symptoms. The relationship between allergen exposure and inflammation of airways and clinical symptoms is complex; factors other than allergens may be involved, such as cold and perhaps also electric charges of the atmosphere [1•, 2•, 6•].

The health consequences of thunderstorm asthma may be prevented with adequate measures, including meteorological forecasting and through the correct use of therapy targeting allergies and asthma. The mechanisms involved in the release of allergens from pollens during thunderstorms and associated risk should be known by physicians, not only by allergists, but also by general physicians (GPs) and pollen-allergic patients to help with prevention efforts. Information about the risk of experiencing an asthma attack is also relevant in patients affected only by seasonal allergic rhinitis. In addition, there is a potential risk of thunderstorm-related relapse of asthma attacks in some patients [35, 36].

The world’s worst recorded thunderstorm asthma attack was on 21 November 2016 in Melbourne, where nine subjects died and more than 8500 were hospitalized in Victoria. It caused many people, including those who had no history of asthma or respiratory issues, to experience mild to severe breathing difficulties and near fatal asthma.

Any serious asthma attack during a thunderstorm can be life-threatening and can also induce tragic consequences of near fatal asthma and of death.

Despite considerable advances in asthma management, large sections of our community are still highly vulnerable to massive outbreaks of asthma with consequences sometimes also severe.

The health consequences of thunderstorm asthma may be prevented with adequate measures by meteorological forecast and by correct use of patients of adequate antiallergic and antiasthma therapy.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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