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RESPIRATORY ALLERGY AND CLIMATIC CONDITIONS

I. *Review*

By

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INTRODUCTION

From studies of literature it is proposed to discuss the various theoretical possibilities of causal relation between climatic conditions and respiratory allergy.

In a following paper the results are presented of a series of experiments to establish the influence of the different electric climates on the allergen content in the air.

Definitions

By respiratory allergy is here meant the diseases, estival fever, vasomotor rhinitis and bronchial asthma.

Estival fever is a fairly well-defined nosologic entity, while vasomotor rhinitis and bronchial asthma are more difficult to define, particularly the latter for which various definitions exist. Very often in the reviewed literature, only the word asthma is used, representing a complex of signs and symptoms caused by a variety of etiological factors. The literature rarely states the criterions governing the use of the words "asthma" or "bronchial asthma", which makes the interpretation of results difficult.

As an intermediate link between clinical pictures and technique stands the idea of polluted air, which means situations where the atmosphere contains particles and chemical substances in concentrations that are harmful to human beings

and their surroundings, and which are produced by human activity (42).

Most meteorological parameters mentioned in medical literature are immediately comprehensible, such as temperature, barometric pressure and relative humidity, as well as direction and velocity of the wind.

On the other hand, parameters such as thermals, temperature inversions, smog and air masses (40) and the electric circuit in the atmosphere (5-14) have to be explained.

Normally the temperature of the atmosphere decreases with height by ca. 0.6°C per 100 m. However, there are two exceptions to this rule: firstly there may be a local superheating of an air mass close to the earth, whereby the specific gravity of this air mass is reduced in relation to the surrounding air. The heated air mass rises, and in this way suspended allergens are transferred to higher strata of air, whence they are spread over a large area. This phenomenon is called thermals.

Secondly, a deviation occurs, if on cloudless days the surface of the earth emits heat by radiation. In relation to the higher strata of air, the strata close to the earth will be cooled, and thus temperature will rise with height up to a certain point. Below this point there are horizontal, but no vertical air flows. The dispersal of allergens in the air—a process, which is accentuated by thermals—is impeded by these climatic conditions, called temperature inversions.

If the underlying cold air of a temperature inversion is moist and contains many condensation nuclei, smog develops.

In the atmosphere, the movement of large air masses takes place over great distances; these are caused by pressure differences due to variations in the sun's heat in various geographical areas, and to the friction between the air and the revolving earth. Where these masses of air meet, "fronts" originate. These air masses are named after their place of origin, e.g. polar continental, polar maritime, tropical maritime and tropical continental air masses. They have a decisive influence on the climate of various geographical regions.

In the atmosphere a series of processes continually take

place, resulting in the origination of electric currents, or expressed in another way, an air electric circuit exists.

In order that currents may pass through a substance, this must contain mobile charged carriers, and there must be an electric field in the substance.

The charged carriers in the air are the so-called atmospheric ions, generated by the liberation of an electron from an originally uncharged air molecule, by which the molecule is left as a single-charged positive ion.

In a fraction of a second the electron will hit upon an uncharged molecule, which is then made into a single-charged negative ion.

The energy required for the ionization may come from various sources, above all from radioactive radiation from substances in the air and on the surface of the earth, and particularly by cosmic radiation in the higher strata.

The originally generated ions, sometimes called primary ions, will rapidly attract water molecules, and with these form molecular complexes consisting of primary ions and 8-10 water molecules. These molecular complexes are called light or small air ions.

The atmospheric ions are generally characterized by their mobility, *i.e.* the ratio of the velocity to the field strength in a fixed electric field. Primarily the mobility depends on the ratio of the charge of the ion to its mass, and concerns small ions of a magnitude $1-2 \cdot 10^{-4} \text{ m}^2 \cdot \text{Volt}^{-1} \cdot \text{sec}^{-1}$.

In places with fair-weather the atmosphere will contain an electric field with an intensity of about $130 \text{ V} \cdot \text{m}^{-1}$, vertically oriented, *i.e.* with a direction that it will make positive charges move towards the surface of the earth. Corresponding to this, one finds that a current with an intensity of ca. $2 \cdot 10^{-12} \text{ amp/m}^2$ meets the earth.

The field strength decreases with increasing height until the intensity is zero at the height of ca. 60 km. This height denotes the bottom stratum of the ionosphere, and between this stratum and the surface of the earth there is a potential difference of ca. $3 \cdot 10^5 \text{ volt}$.

Provided that no other electric processes than the above mentioned took place in the atmosphere, the potential difference between the ionosphere and the earth would vanish in approximately 30 minutes. The reason why this potential difference—and thus the electric field—is preserved, is the effect of the so-called thunder-storms. In places where the thunder-storm systems occur the aerial electric field is reversed compared with that of fair-weather conditions. Furthermore the field strength is much greater ($1000-100,000 \text{ V} \cdot \text{m}^{-1}$). By this, positive charges are forced towards the ionosphere, and the calculations disclose that this happens to an extent which may explain the preservation of the fair-weather field.

The above mentioned processes make up the air-electric circuit. In their extensive monographs on the subject, *Israel* (14) and *Chalmer* (5) describe these problems in more detail.

Literature Review

The possible influence of various climatic factors on respiratory allergies was discussed even by Hippocrates and Galen. Theoretically the influence may be due to a *direct* effect upon the bronchial-, nasal or tracheal mucosa of one or more climatic parameters which act as direct irritant. It may be a question of temperature, and relative humidity, barometric pressure, wind, thunder and rain, as well as the electric conditions of inhaled air as first suggested by *F. Dessauer* (7).

As an alternative, climate may *indirectly* affect the respiratory allergic by giving rise to conditions which promote the growth of pollen-carrying plants; this also includes conditions which promote pollination, various allergen contents as *e.g.* in sea air and air masses from the mainland as well as the occurrence of temperature inversions with increased allergen concentration in the air.

As is maintained by *Ordmann* (33), climatic parameters may indirectly affect the patient with a respiratory allergy by changing the "toxicity" of the allergen, *e.g.* by changing the water content of the allergen or by changing its electric charge.

Direct Effect of Climatic Conditions on Respiratory Allergies

In 1897 *Solly* (39) found that the most characteristic meteorological parameters affecting patients with asthma was the increase and decrease in barometric pressure. On the other hand, *Leopold & Leopold* (1925) (23) found that barometric pressure and relative humidity of the air only slightly affected the clinical symptoms in asthmatic patients. They found that atmospheric conditions preceding gales or sudden shifts from warm to cold fronts yielded asthmatic symptoms in two patients in an air-conditioned, dustfree room. Under similar conditions, *Nelson* (1933) (31) found that a sudden drop in temperature, a considerable increase in relative humidity and a drop in barometric pressure produced symptoms in ragweed asthmatics. One of Nelson's collaborators, *B. Z. Rappaport* (36) found that 7 patients with bronchial asthma (pollen allergies) had asthmatic attacks that coincided with a very large drop in the barometric pressure. In a study of 500 patients, *Evers & Schultz* (1933) (9) found that dry air and great variations of temperature were harmful to asthmatics. In 1939 *Mohr* (27) found that one half of the asthmatic attacks in 52 children coincided with a shift in wind direction. However, in 1963 *Newell & Swafford* (32) found quite opposite results.

Peskin (1959) (35) observed that climatic conditions only slightly affected the clinical picture of asthma in children. In 1956 *Buston* (4) found similar results on examination of 18 asthmatic children. However, his group contained one or two patients who reacted with prolonged FEV₁ at a temperature below 15° C.

Using an epidemiologic technique, *Greenburg et al.* (1956) (10) compared the incidence of acute asthmatic admissions in three large New York hospitals in relation to climatic conditions, pollution of air and allergen content of the air. There were days when there was a considerable increase in admissions of acute asthmatic attacks. These critical days could be signi-

ificantly correlated with a simultaneous fall in temperature to below 15°C , while pollution of air, spore- and pollen-count were found to be unchanged in relation to the period before and after the critical days.

In 1931 *Dessauer* (7) published the results of 10 years work on electric conditions in the air and their biological effect. It was a pioneer work which mainly dealt with technical conditions, although it contained a clinical section with postulates on the effect of "ion-enriched" air on respiratory symptoms and hypertension.

This study started a long series of examinations on the biological effect of ionized air, and part of these papers deal with the relation between respiratory symptoms, allergy and ionized air.

Thus in 1958 *Kornbluh et al.* (18) published a paper on the treatment of 74 acute allergic attacks. This treatment consisted of inhalation of an atmosphere with a surplus of small negative ions. In 64 per cent of the cases the treatment administered was effective, although only temporarily so. This work was somewhat criticized, as he did not explain the type of allergy concerned (no skin tests, no eosinophile count). Nor did he provide controls consisting of a similar number of allergies staying in the same room, but inhaling normal room air. Finally it was a shortcoming that the effect was estimated without objective criterions.

By a clinical examination in 1960 *B. Zylberberg & M. N. Loveless* (44) attempted an estimation of respiration in attack-free asthmatics (without further definition) simultaneous with exposure to an atmosphere rich in alternating positive and negative small ions.

The study was carried through as a double-blind experiment with the intention of evading an essential part of the bias- and placebo effect, which always exists in this kind of experiment. They concluded that there were no changes of the degree of the spasmodic respiration of the asthmatics examined at exposure to "ion-enriched" air.

In patients with paroxysmal dyspnoea of bronchio-spas-

modic character, *Bechgård & Vad* (1963) assessed the attack-reducing effect of an ion generator for home use. The ion generator yielded more small negative than small positive ions. A clinical improvement was seen, *i.e.* fewer asthmatic attacks in about 41 per cent of adult cases and 60 per cent of the children. The lack of controls and measurable criterions is open to objection.

A very accurate investigation was recently reported by *Motley & Yanda* (1966) (29), where by a large spectrum of lung function tests 46 emphysematous patients were examined before and after inhalation of small positive and negative ions in a quantity of ca. 500.000 per cm^3 air (normally 200–800 per cm^3 air). The patients were selected according to a history of paroxysmal dyspnoea of bronchial spasmodic character, combined with lung function tests, indicating pulmonary emphysema. They concluded that their work showed no significantly objective changes in the patient's lung function following exposure lasting for a couple of hours. Out of these 46 patients, 35 were provided with an ion generator at home for two weeks. The ion generator yielded negative small ions in the same quantity as in the short exposure test. No reliable changes occurred in the function tests in this group either.

In an investigation into asthmatic bronchitis in infants, the findings of *J. Palti et al.* (1966) (34) were the reverse. They assessed the clinical picture in 13 children during inhalation of about 10^4 negative small ions/ cm^3 air, and found more rapid improvement in these than was expected from the experience of the treatment of this disease in other hospitals. However, the clinical data of the controls are not accounted for, and the clinical course of the two groups is not followed in the same way.

Krüger & Smith (1957) (20) broke a new trail in the examination of the effect of ion-enriched air on patients with a respiratory allergy. They examined the effect of high ion concentrations on the self-cleansing mechanism of the tracheal mucosa, above all of the ciliary activity. By in-vitro experiments they found that positive ions impeded the ciliary ac-

tivity, and at the same time the tracheal mucosa became more vulnerable. Small negative ions had an accelerating effect on the ciliary rate. In a more recent work (31) they postulated that negatively ionized ozone had a swift reaction with some porphyrins, which are responsible for ciliary activity. One of the shortcomings of this fundamental work on the sensitivity of the ciliary rate at various ion climates, is that it is not known how many experiments were performed, nor can the range of the established results be estimated.

In an attempt to re-examine the results of *Krüger & Smith, Andersen* (1965) (1) observed in a very exact and well-documented paper that "it is impossible to demonstrate the postulated effects of high positive or negative ions on ciliary activity". However, Andersen does not conclude that small ions whether negative or positive, cannot affect the ciliary activity, provided the examination is performed in another way.

Indirect Connection between Respiratory Allergy and Climatic Conditions

The indirect effect of climatic conditions on respiratory allergies may occur when these conditions increase the concentration of specific or non-specific allergens in the air breathed by the allergic, or when the "toxicity" of these allergens is changed.

Atmospheric pollen and spore concentration shows seasonal and daily as well as climatic fluctuations. *Hirst et al.* (1953) (13) and *Hamilton* (1957) (12) measured the 24-hour-concentration of spores and pollen while simultaneously registering climatic conditions.

In most species they found that the concentration of pollen and fungus spores in the air decreased during and after a shower, while the ascospore concentration increased under similar circumstances. It seems as if humidity is necessary for the liberation of these spores. The concentration of other species of spores (hyalin, basidiospore) is not affected by rain.

Most pollen and spore species were found with increasing frequency at rising temperature and rising relative humidity levels, whereas the grass pollen concentration fell with increasing humidity. The cause for the diurnal fluctuations probably also depended on the climate. Hirst found that the spores, most frequently found in the morning, demanded hygroscopic variations in the opening of the sporangium in order to be liberated. In the afternoon the pollen and spores most frequently found were those whose liberation required a passive vibration of the stamen, produced by the wind, as well as low humidity. Dew or other forms of humidity were necessary for the liberation of ascospores, and so the concentration was highest in the evening and at night.

In recent years attention has been drawn to the occurrence of a number of polluting particles in the air from industrial and city areas (40, 26), as well as towards its importance in the clinical picture of respiratory allergy.

The substances studied were sulphur dioxide, carbon monoxide, carbonic hydrogens, nitrogen oxides, ozone and a number of undefined particles. The influence of the climate on the pollution of air is very great, conf. the great catastrophies at Donora 1948, London 1952 and 1962. These catastrophies were a combination of stable temperature inversions and a heavy increase in air pollution, especially sulphur dioxide concentration.

Measurements of the nuclear number over great cities, London and Potsdam (14) showed figures of 50.000-100.000 nucleii per cm^3 and lower values were found over purely residential quarters; in mountainous areas nuclear figures of 1.000-3.000 per cm^3 were found.

The constant air masses from polar and tropical regions are of very varying nuclear content. *Landsberg* (22) found low values in polar maritime air and high in the tropical continental air. This tropical continental air mass is known in the Mediterranean region as the Foehn, which from ancient times has been feared because of its effect on human beings and animals.

In what way is the respiratory allergic affected by pollution of air?

Solutions to the problems have been sought, partly from epidemiological studies, and partly from clinical and experimental studies. By following the asthmatic attacks of 84 patients *Zeidberd* (1961) (43) found that the attacks in 49 patients were correlated to the sulphur dioxide content of the air. On the other hand, no correlation was found between this and the asthmatic attacks in 35 children.

In 1961 *Schoettlin* (38) found that the asthmatic attacks in 137 patients had little relationship to the content of sulphur dioxide as well as to other chemical substances in the air, while he found a correlation between asthmatic attacks and the sensitivity of plants to air pollution.

A smog period in 1953 (10) in New York showed very high concentrations of sulphur dioxide, but in 5 large New York hospitals the number of admissions with asthma did not increase during this period.

In clinical experiments *Motley et al.* (29) found that respiration in polluted Los Angeles air aggravated the degree of emphysema in a number of patients. Furthermore they found a characteristic fall in the residual volume in patients with emphysema, who for some time had breathed clean air.

In animal experiments *Lawther* (1965) (25) found that respiratory resistance might be increased by inhalation of mixed pollutions of air, but the character and the compounds of the mixture were of decisive importance to the degree of dyspnoea.

The geographical distribution of bronchial asthma shows an increased mortality rate in countries such as Holland, Great Britain and Denmark as well as the coasts of Norway and Sweden.

Kraepelin's (19) investigation of Swedish children showed a mortality from bronchial asthma of 0.73 per cent for the entire country, while in Stockholm, which has a low and damp situation, the mortality rate is 1.73 per cent.

In patients allergic to house dust, *Ordmann* (33) found a

difference in the concentration of house dust antigen from the mainland and from the coast.

Vallery-Radot (41) found a difference in the mortality rate for house dust asthma in patients living at the banks of the Seine, compared with those in other residential areas in Paris. *Rimington* (37) explained these conditions by stating that the moist atmosphere increased the growth of fungi and bacteria, and their biological effect on the house dust was responsible for the changed concentration in house dust from the coasts. However, *Davis* (6) did not demonstrate more fungi in the allergen part of the house dust from moist climates than from dry climates.

Ordmann (33) assumed that house dust from the coasts had "normal" concentration, while house dust from the mainland had reduced concentration. This was probably caused by ultra-violet radiation and also an influence through ionization with consequent decomposition of living tissue and changed biological processes in the large heterogenous mass, which constitutes house dust.

Recently *Voorhorst* 1964 (41a) has suggested that mites *Dermatophagoides* might be the source of the house-dust allergen. *Spieksma* 1967 (39a) has later shown, that there is a causal relationship between the number of mites and the allergen content of a house-dust sample. In a proper nutrient medium a temperature near 25° C and a high relative humidity give the highest growth rate for the mites. Very recently *Miyamoto & Oshima* 1968 (26a) has found an allergenic identity between the common floor mite and house-dust.

DISCUSSION

From the literature reviewed it is apparent that an investigation of the susceptibility of respiratory allergies to climatic conditions is difficult. Numerous workers reach varying and often contradictory results. One of the reasons for this discrepancy may be that the patient group examined is too heterogenous, as it includes patients with bronchial asthma, e.g. pol-

len allergics, as well as patients with paroxysmal dyspnoea of different genesis. A priori, different groups cannot be expected to show identical susceptibility to climatic factors and so statistical studies are of minor value. From current clinical classifications of respiratory allergy it may be possible to identify one group, characterized by a particular susceptibility to climatic variations.

The literature on the direct susceptibility of respiratory allergics to climatic conditions has concentrated on two main problems: firstly the climatic factors known from of old: barometric pressure, temperature and the relative humidity of the air, and secondly the electric climate of the air.

Generally the first mentioned climatic factors are interdependent in nature. In this connection the cold front is most characteristic, occurring on a sudden drop in barometric pressure, followed by the intrusion of a cool polar air mass. The temperature of the air will fall to dew point and fog and rain will follow. When this sequence occurs, it is difficult to indicate which of the changed parameters eventually affect the patients with bronchial asthma.

According to the literature, however, it seems likely that a drop in air temperature to below 15°C is among the provoking factors in bronchial asthma. This purely empirical observation is supported experimentally by the investigations of *J. S. Millars et al.* (1965) (31) on FEV_1 in asthmatics before and after exposure to cold. He found reduced FEV_1 on exposure to cold, and so did *Buston* (4) in some patients.

The importance of barometric pressure as a direct irritant on the respiratory allergic is not clearly established. The natural variations of pressure occurring at the surface of the sea amount to 5–8 cmHg. Identical variations of pressure may occur when flying to 800–1200 m, but the author does not know whether attacks of bronchial asthma frequently occur during take-off and landing. Smaller, but still rapid variations of pressure without simultaneous change of temperature occur in the lifts of taller houses. But variations of pressure generated here are not known to provoke bronchial asthma.

The importance of air electric conditions in respiratory allergy is not finally defined, but it seems as if this factor has been somewhat exaggerated. It appears that the more painstaking and exact the investigations that are performed (1), (29), the more difficult it is to demonstrate the effect of the electric conditions—especially the effect of small ions in allergic conditions.

The author thinks that from the present investigation it is not obvious that air electric conditions—including ions—affect respiratory allergics. The problem may probably be solved by investigations of patients in climate rooms, where the patients are selected according to careful allergologic examination.

The most important factors in provoking attacks in respiratory allergics are those dependent on climate, *e.g.* the microbiology of the air and the degree of air pollution. In these the important of these two factors is generally accepted and will not be discussed here. On the other hand, the climatic conditions that result in inhalation by respiratory allergics of harmful allergens are underestimated in literature.

As the micro-biology varies with the climate, so that *e.g.* some patients become symptom-free after a shower, whereas in others their symptoms are precipitated, and so complete control of airborne allergens is necessary in investigations of climatic factors.

The importance of the indirect effect of climatic conditions on respiratory patients may best be illustrated by the mortality statistics of the smog period 1952 (24) in London. There was an increased mortality of about 4000 patients during the catastrophe, which was a combination of heavy pollution of air and a constant temperature inversion. Most of the fatal cases were patients with chronic respiratory diseases.

In the author's opinion the indirect effect of climate on patients with respiratory allergy are quantitatively of far greater importance than the direct effect of temperature and probably air electric conditions.

SUMMARY

As an introduction several definitions are discussed concerning respirator allergy and climatic conditions. Various meteorologic conditions are described in detail, including the electric climate of the air.

The possible influence of the climate on the respiratory allergies may either be a direct effect of one or more climatic factors, or an indirect effect where climatic conditions increase or decrease the concentration of air-borne allergens that are harmful to the patients.

The literature on this subject is reviewed, and it is concluded that a drop in air temperature to below 15°C may cause bronchospasms in some patients.

The electric conditions of the air is discussed fully, partly as the cause of attacks and partly as factor impeding the frequency of attacks in respiratory allergies.

According to the present literature the author considers that there is no direct correlation between the electric climate in the air and attacks of dyspnoea in asthmatics.

Emphasis is laid upon the importance of the effect of the climate on the concentration of airborne allergens.

The quantitative importance of the direct climatic effect on the patient is small compared with the importance of the climatic effect on allergens, and hence an indirect effect on the patients.

(For references see p. 472-474).

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