

Influence of Small Atmospheric Ions on the Airways in Patients with Bronchial Asthma

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The influence of artificially generated atmospheric ions is studied in 15 patients with bronchial asthma. A slight but significant (at 5% level) improvement in the lung function was demonstrated in nine patients during positive as well as negative ion exposure, but the patients' subjective ratings of the air quality did not show any changes due to ion exposure. No change in the histamine threshold of the airways in six patients with bronchial asthma was demonstrated during exposure to ions. Further controlled studies with electro-aerosols are needed.

Key words: asthma bronchiale, atmospheric ions; histamine provocation.

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Patients with bronchial asthma suffer from a general hyperreactivity in the airways to a number of stimuli in the inhaled air such as pollen, dust, fumes, cigarette smoke, and changes in the weather. Atmospheric ions are often claimed to interfere with asthmatic disease, but very few controlled studies concerning the influence of ions on bronchial asthma have been carried out (2,9). Nevertheless, ion therapy is widely used throughout the world and ion generators for home treatment are available although we still do not know whether they have any influence on the airways.

The purpose of this study was to examine the influence of atmospheric ions on the reversible obstruction in the airways of patients with bronchial asthma and the hyperreactivity of the mucosa measured by the histamine sensitivity in the airways. Further studies based on experience from this study will take place.

MATERIAL AND METHODS

Patients

Fifteen patients (Tables 1 and 2) with bronchial asthma hospitalized in the medical department for an extended allergy testing took part in this trial on the influence of artificially generated small atmospheric ions on the lung function.

Seven women and eight men aged between 16 and 48 years and with a duration of asthma from 2-43 years were tested. 11/15 (73%) had a hereditary factor, 7/14 (50%) had elevated immunoglobulin E (IgE) and 13/14 (93%) elevated eosinophilic cells in the peripheral blood. 9/15 (60%) had extrinsic allergy.

All patients claimed they developed an asthma attack when exposed to one or more unspecific agents such as fog, smoke and change of weather.

Table 1
Data for patients included in the study of LF during exposure to ions

No.	Sex	Age (years)	Asthma duration (years)	Hereditary factor +/—	IgE ^a	Eos ^b	Extrinsic allergy +/—	FEV ₁ (N ^c)
4	M	48	3	+	334	2,838	—	2.1 (2.9)
5	F	43	6	+	169	1,800	+	1.3 (2.6)
6	M	17	10	+	861	1,813	—	1.1 (4.3)
7*	F	36	3	—	158	1,269	—	1.3 (2.7)
8	M	43	38	+	89	406	—	1.3 (3.6)
9	F	36	13	+	217	1,169	+	2.0 (2.8)
10	M	44	2	+	378	700	+	1.9 (4.0)
11	F	46	43	—	760	1,250	+	0.5 (2.6)
12	M	16	13	+	943	706	+	1.5 (4.3)
14	F	33	28	+	148	525	—	2.3 (5.2)

* Excluded from the study as the LF decreased before ion exposure due to the effort of measuring the FEV₁.

^a IgE range (adults) 3–263 U/ml.

^b Blood eosinophilic cells, normally < 350 m/l.

^c Normal values of FEV₁/l in a person of corresponding sex, age and height.

The patients were divided into group 1 (Table 1) and group 2 (Table 2).

Group 1 comprised 10 patients with reversible obstructive lung disease and decreased lung function (LF) without medicine (Table 1).

The initial FEV₁ (forced expiratory volume in 1 sec) in relation to normal FEV₁ ranged from 19%–72%. The patients were exposed to ions while the lung function was recorded at short intervals (see experimental design).

Group 2 comprised six patients, including one from the exposure trial (Group 1, No. 10). All patients had bronchial hyper-sensitivity to histamine. The sensitivity to histamine was assessed by the amount of histamine inhaled in 1 ml saline for a decrease in LF (FEV₁) of 25% or more. A low histamine threshold is typical for bronchial asthma and characteristically, it remains unchanged in the same patients when repeated weeks or months afterwards. The

Table 2
Data for patients included in the study concerning the histamine threshold during ion exposure

No.	Sex	Age (years)	Asthma duration (years)	Hereditary factor +/—	IgE ^a	Eos ^b	Extrinsic allergy +/—	Histamine threshold (µg)
3	F	24	12	+	—	—	+	200
10	M	44	2	+	378	700	+	100
13	F	19	8	+	142	506	+	50
15	M	21	5	+	164	900	—	50
16	M	36	5	—	392	138	+	300
17	M	35	7	—	916	506	+	100

^a IgE range (adults) 3–263 U/ml.

^b Blood eosinophilic cells, normally < 350 m/l.

patients were provoked with histamine while exposed to ions.

All patients were known to react more sensitively than normal to histamine. While people normally inhale 1,000 μg histamine or more without changes in lung function all patients included in this experiment had a histamine threshold between 50 μg and 300 μg histamine (Table 2).

Both trials (exposure- and histamine provocation), which were blind, were carried out with the patients sitting in the cabin (telephone plast box) facing the ion generator (Figs 2 and 3). The same procedure was used when changing the ions from 0 (no ions) to negative or positive ions. The patients were not informed that ions were involved and that the conditions would be changed. All patients were asked to relax while sitting in the cabin; the patients breathed in and out through the nose or mouth as convenient. All patients were acquainted with the provocation room, the cabin, and the lung function apparatus (Spirotron[®], Dräger, West Germany). They could ordinarily reproduce their own $\text{FEV}_1 \pm 5\%$. No one had taken medicine 6–12 h before the trial, as it might interfere with the lung function.

The lung function test was performed as FEV_1 . The normal values were evaluated from a nomogram according to sex, age, and height.

The histamine threshold of the airways was determined by increasing the amount of histamine inhaled with 1 ml saline and measuring the FEV_1 afterwards. A positive reaction was defined as a decrease in FEV_1 of 25% or more compared with initial FEV_1 . The inhalation was carried out by means of a Pari-inhalierboy[®]. One millilitre solution was nebulized in approximately 5 min. The patient activated the inhalator during the inhalation by means of a contact and the whole nebulized volume reached the airways. After the inhalation the FEV_1 was measured every 5 min. One millilitre saline with a successively

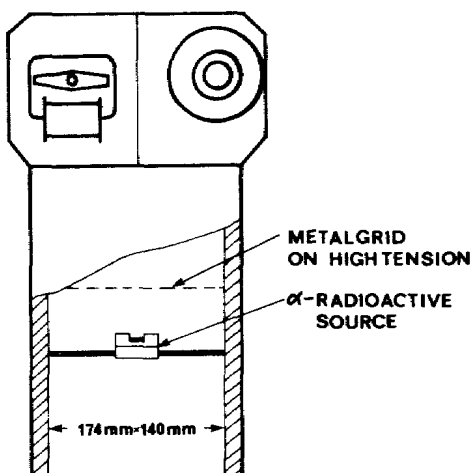


Fig. 1. Ion generator used. Air is blown downwards by the two ventilators on the top.



Fig. 2. Position of the patient in the cabin facing the ion generator.

increasing amount of histamine: 10, 20, 50, 100, 200, 300 and 500 μg was prepared just before use.

The serum IgE was determined by means of the paper radioimmunosorbent technique (PRIST) (3). The error of analysis was about 10%. All determinations were the average of double determinations. The normal values for adults range from 3 to 263 U/ml (1 U is approximately 2.5 ng).

Ion generator

The ion conditions to which the subjects were exposed were obtained by means of an ion generator mounted in the cabin. The generator is shown in Fig. 1, and when mounted in Figs. 2 and 3. The generator blew air downwards passing an alpha-radioactive source (Am-241) that produced pairs of ions. Unwanted ions were captured by a metal grid held at high voltage. The concentrations and mobility spectra were measured by a cylindrical condensor with suitable galvanometer amplifier and recorder (4).

Measurements showed that the ions produced by the generator had mobilities greater than $8 \times 10^{-5} \text{ m}^2/\text{Vs}$. Characteristics (4,5) of the ion content in the air from the generator were measured for positive as well as for negative ions (Table 3).

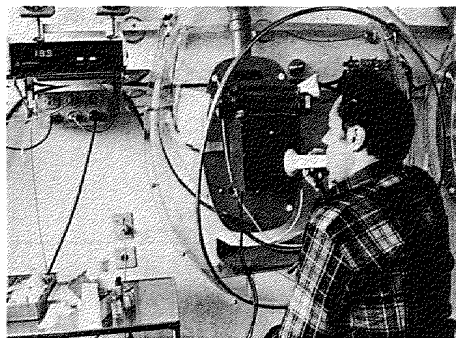


Fig. 3. Facing the ion generator in the cabin the patient blows into the expiration tube, which is connected to the lung function apparatus in the upper left-hand corner.

Table 3

Concentrations of ions measured in the cabin near the face of the patient

	Concentrations: ions per cm^3		
	Positive	Negative	No ions
Positive ions measured	30,000 (5,000)	700 (300)	60 (50)
Negative ions measured	700 (300)	32,000 (5,000)	35 (50)

s.d. of determinations are in parenthesis.

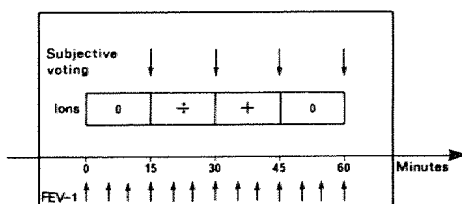


Fig. 4. Experimental design during ion exposure.

How do you feel the air —

cold ————— warm

stuffy ————— fresh

How do you feel the breathing —

troubled ————— easy

Fig. 5. Questionnaire for subjective votings.

As high concentration a value of approximately 30,000 ions per cm^3 was used for positive as well as for negative ions. For conditions without ions the generator was run without the high voltage on and the radioactive source was replaced by a dummy. In this case concentrations of positive and negative ions were about 50 ions per cm^3 .

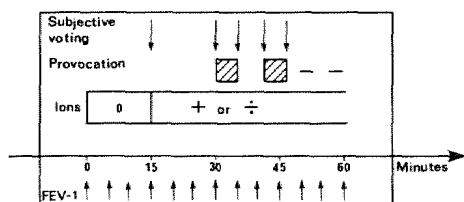


Fig. 6. Experimental design during histamine provocation.

The ion concentrations in the cabin were measured with the intake of the measuring condensor placed at face level. The patients were not electrically earthed.

Experimental design

Exposure to ions. Ten patients (Table 1) were successively exposed at 15-min intervals to 0-, negative-, positive- and 0- ions (Fig. 4). FEV₁ was recorded every 5 min. After each ion period the patients were given a questionnaire (Fig. 5) in which they were asked to vote on three conditions concerning: 1) temperature, 2) air freshness, and 3) ease in breathing. The votings were made by setting a pencil mark on an arbitrary 15-cm scale. The markings were afterwards measured in percentage of scale-length from the middle (Table 5). The trial was uninterrupted and lasted for 1 h.

Histamine provocation during ion exposure. Six patients (Table 2) were given no ions for the first 15 min, after which they received positive or negative ions (Fig. 6). After 15 min of active ion exposure, provocation with histamine began in increasing concentrations: 10, 20, 50, 100, 200, 300 and 500 µg histamine in 1 ml saline until there was a decrease of 25% or more in FEV₁. The patients voted in a questionnaire as at the exposure trial. Only one histamine threshold was recorded in 1 day, all within a week, and the changes in FEV₁ from 0- to positive ions and 0- to negative ions were calculated.

RESULTS

Lung function during ion exposure

The lung function values during ion exposure are presented in Table 4. One patient, No. 7 (Table 1), was excluded from this study as her lung function decreased more than 25% before the ion exposure due to the effort involved in lung function measurement. For the nine patients included, the initial FEV₁ compared with the normal values ranged from 19%–72%. The relative FEV₁ values during ion exposure, both negative and positive, were increased although the changes were rather small.

Table 4
Change in FEV₁ during ion exposure. All values are based on three determinations

No.	Initial FEV ₁ (normal values)	FEV ₁ relative to initial FEV ₁ during:			
		No ions 0–15 min	Neg. ions 15–30 min	Pos. ions 30–45 min	No ions 45–60 min
4	2.1 (2.9)	1.05	1.08	1.10	1.00
5	1.3 (2.6)	0.92	1.00	1.05	1.00
6	1.1 (4.3)	1.12	1.12	1.15	1.21
8	1.3 (3.6)	1.08	1.06	1.00	0.97
9	2.0 (2.8)	1.08	1.13	1.17	1.12
10	1.9 (4.0)	1.07	1.02	0.95	0.83
11	0.5 (2.6)	0.93	0.93	1.20	1.13
12	1.5 (4.3)	0.91	1.18	1.14	1.05
14	2.3 (3.2)	1.01	1.03	1.03	0.99
Average	—	1.02	1.06	1.09	1.03

s.d. of observed values are 0.05–0.10. For details, see text.

Table 5
Subjective votings in per cent during ion exposure

No.	Temperature				Air freshness				Ease of breathing			
	0	-	+	0	0	-	+	0	0	-	+	0
4	-22.5	0.0	-32.0	- 1.3	25.3	- 5.3	46.7	- 1.3	17.3	- 2.7	34.7	1.3
5	-12.0	-76.0	28.0	—	17.3	68.0	- 4.0	—	80.0	74.7	57.3	—
6	- 8.0	- 9.3	-12.0	-10.7	40.0	40.0	37.3	45.3	0.0	2.7	30.7	41.3
8	-48.0	-16.0	-24.0	-13.3	33.3	36.0	21.3	10.7	2.7	2.7	4.0	2.7
9	-42.7	0.0	-21.3	-29.3	69.3	12.0	40.0	69.3	86.7	77.3	62.7	82.7
10	- 8.0	- 9.3	- 9.3	- 5.3	9.3	10.7	9.3	6.7	8.0	10.7	5.3	5.3
11	-33.3	-32.0	-38.7	-42.7	41.3	42.7	30.7	62.7	-30.7	-26.7	-46.7	-50.7
12	-26.7	-40.0	-16.0	13.3	48.0	12.0	5.3	-20.0	-29.3	- 6.7	-10.7	- 8.0
14	29.3	12.0	-41.3	6.7	88.0	13.3	85.3	8.0	84.0	32.0	78.7	52.0

According to the Friedman test (7) a significant difference between the four periods was present ($P < 0.04$). From the individual FEV₁ values it appeared that during exposure to negative ions 20/27 values were increased compared with the initial values; during positive exposure 21/27 were elevated. Only 13/27 were higher than the initial values during the final 0-ions period.

Table 5 shows the subjective votings during the ion exposure periods. Most of the patients felt the air was cold, but there was no general trend during the different periods. According to the Friedman test no difference was present ($P = 0.2$). Most of the patients felt the air fresh without any change during the periods. No significant changes were demonstrated ($P = 0.3$). Finally, no changes in ease of breathing were demonstrated ($P = 0.7$).

Histamine provocation during ion exposure:

Table 6 shows the LF after histamine provocation for the six patients included in the study during exposure to positive or negative ions.

No significant change in the histamine threshold could be demonstrated during the different periods according to the Friedman test ($P = 0.4$) (Table 6). Relative changes in

FEV₁ from periods of 0- to positive and 0- to negative ions are included in Table 7.

No relative changes in FEV₁ values were demonstrated during the changes from 0- to positive ions or from 0- to negative ions before the histamine provocation. Wilcoxon's test for matched pairs (7) was used.

DISCUSSION

In this study a slight but significant (5% level) increase in LF (FEV₁) has been demonstrated in patients with bronchial asthma during exposure to positive as well as negative atmospheric ions. The improvement in LF was small (Table 4) and was not followed by any changes in the subjective votings concerning the air quality (Table 5). For the nine patients involved in the ion exposure study it was known that bronchodilators which act on the muscular spasms were able to improve LF to nearly normal.

The small improvement in lung function during ion exposure together with the high ion concentrations used in this study cannot explain the relief of asthmatic symptoms stated by some asthmatic patients to be due to changes in the weather or to ion therapy. The ion concentrations used in this study, about 30,000 ions per cm³, may be characterized as high though not extremely high. Under normal conditions indoor or

Table 6

Initial FEV₁ values, and the relative values after successive histamine provocations

No.	Ions	Initial FEV ₁	Relative FEV ₁ values after provocation µg histamine						
			10	20	50	100	200	300	500
3	0	2.3	0.91	0.78	0.86	0.77	0.61*		
	+	2.5	—	—	1.05	0.85	1.03	0.84	0.46*
	—	2.4	1.11	1.19	1.07	0.95	0.55*		
10	0	3.0	1.05	0.93	0.92	0.81	n.d.		
	+	2.7	—	0.91	0.99	0.65*			
	—	2.6	—	0.94	0.88	0.73*			
13	0	2.0	0.81	0.69*	0.54*				
	+	2.0	0.86	0.81	0.58*				
	—	1.6	1.06	0.45*	—				
15	0	1.8	0.91	0.87	0.42*				
	+	2.4	0.85	0.87	0.51*				
	—	1.7	1.00	0.92	0.58*				
16	0	2.0	1.04	1.09	1.04	0.97	0.97	0.69*	
	+	2.0	—	—	1.03	0.89	0.79	0.74*	
	—	1.8	—	—	1.14	1.22	1.22	1.06	0.76*
17	0	3.6	0.91	0.80	0.71*				
	+	4.2	0.94	0.89	0.83	0.66*			
	—	3.0	1.12	1.03	1.04	0.92	0.94	0.94	0.69*

n.d.: no determination of 200 µg histamine response.

*: FEV₁ decrease of 25% or more of initial value.

Table 7

Relative changes in FEV₁ from 0- to positive- respectively negative ions carried out on different days

No.	Initial FEV ₁	Relative changes in FEV ₁ from	
		no ions to pos. ions	no ions to neg. ions
3	2.47	1.06	0.98
	2.43		
10	2.73	0.95	0.86
	2.57		
13	1.97	1.07	1.07
	1.57		
15	2.37	0.93	1.05
	1.67		
16	2.03	1.10	1.08
	1.80		
17	4.23	1.00	1.08
	3.00		

outdoor concentrations are found at a level of 100–2,000 ions per cm³ (6). Much higher ion concentrations may be found in special weather conditions and certain industrial activities.

The improvement during ion exposure could be due to a local effect of the ions on the hyperreactive irritant receptors within the airways in patients with bronchial asthma. Changes in the bronchial reactivity to histamine were not demonstrated in the group of six patients (Table 6) in this study.

A large number of experiments on the application of artificially generated ions on humans and animals have been published, and it appeared that the effects of ions were better on ill than on healthy people. Experiments on patients with diseases of the respiratory tract (asthma, hay-fever) showed that negative ions in general had a beneficial

influence whereas the positive ions had no, or a detrimental effect. The literature concerning atmospheric ions, electro-aerosols and physical medicine has been reviewed by Wehner (8), Knoll et al. (6) and Andersen (1).

Most of the publications concerning the influence of ions on the respiratory tract are uncontrolled, the reproducibility of the results are poor, and have not been confirmed by others (2,9). All doctors working with patients with bronchial asthma know the great placebo effect connected with introduction of a new therapy. This study was carried out as a controlled blind study with one of the authors (O.A.) helping the medical staff change the ion conditions.

It is known that unipolar electric charges may influence the deposition of aerosol on the respiratory tract. It is possible that the influence of atmospheric ions on bronchial asthma is due to electrically charged aerosols. In a future study the influence of atmospheric ions and electro-aerosols on the allergen-induced bronchospasm will be investigated.

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