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Changes in specific airways conductance and forced expiratory volume in one second after a bronchodilator in normal subjects and patients with airways obstruction

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Skinner, C. and Palmer, K. N. V. (1974). *Thorax*, **29,** 574–577. **Changes in specific airways conductance and forced expiratory volume in one second after a bronchodilator in normal subjects and patients with airways obstruction.** Specific conductance (SGaw) and the forced expiratory volume in one second (FEV_1) were measured in 10 normal, 10 asthmatic, and 10 obstructive bronchitic subjects before and after aerosol salbutamol. Mean SGaw increased by 37% in normals, by 109% in asthmatics, and by 38% in obstructive bronchitics. Mean FEV_1 increased by 2% in normals, by 32% in asthmatics, and by 12% in obstructive bronchitics. SGaw appears to be a more sensitive indicator than FEV_1 of changes in airways calibre following a bronchodilator drug in normal subjects, but FEV_1 is as good an indicator of these changes as SGaw in patients with airways obstruction.

The effect of bronchodilator drugs on diffuse airways obstruction is commonly assessed by measuring changes in the forced expiratory volume in one second (FEV_1). However, bronchial calibre is only one of several factors which determine the FEV_1 (Pride, 1971) so that this test reflects only indirectly the resistance of the intrapulmonary airways. It has been claimed that direct measurement of airways resistance during quiet breathing or panting in a body plethysmograph is a more sensitive test of changes in airway calibre and, therefore, that in the assessment of the response to bronchodilator drugs, this measurement is preferable to the FEV_1 (Lloyd and Wright, 1963; Feinsilver, 1966; Cohen, 1969).

The aim of the present study is to compare changes in FEV_1 and in the direct measurement of airways resistance following administration of salbutamol by pressurized aerosol in normal, asthmatic, and chronic obstructive bronchitic subjects.

PATIENTS AND METHODS

Ten normal, 10 asthmatic, and 10 obstructive bronchitic subjects were studied. The details are given in Table I. The normal subjects were all non-smokers, free from respiratory disease, and the mean FEV_1 and specific airways conductance (SGaw) were within the normal range. The asthmatic subjects were also non-smokers and had blood and/or sputum eosinophilia, and six had positive skin tests to several common allergens; the FEV_1 and SGaw were both reduced at

TABLE I

DETAILS OF SUBJECTS STUDIED

	No.	Sex	Mean Age (yr)	Mean FEV_1 (l. ATPS)	Mean SGaw (ml/sec/cmH_2O/l.)[1]
Normal	10	M	24	4·43	189
Asthmatic	10	7M 3F	34	1·35	33
Bronchitic	10	M	62	0·84	29

[1]Normal range for SGaw 114–414 ml/sec/cmH_2O/l.

the time of the study. The obstructive bronchitics were all heavy cigarette smokers, or had formerly been heavy cigarette smokers, none had positive skin tests and none had blood or sputum eosinophilia. In these subjects also, the mean FEV_1 and SGaw were reduced.

Forced expiratory spirograms were obtained with a dry-wedge spirometer and from the best of three attempts the FEV_1 was recorded in litres (ambient temperature pressure saturated [APTS]). Airway resistance (Raw) and thoracic gas volume (TGV) were measured simultaneously in a constant-volume body plethysmograph at low flow rates. The result was expressed as specific airways conductance, which is the reciprocal of airways resistance per litre of thoracic gas volume ($1/Raw \times TGV$). This measurement takes account of the fact that bronchial calibre and hence airways resistance varies with lung volume. Each reading was the mean of three determinations, and statistical analysis was performed on the logarithms of the SGaw values since the distribution of SGaw is lognormal or skewed (Guyatt and Alpers, 1968).

The measurements were made at the same time of the day, before and 10 minutes after the inhalation of 200 μg of salbutamol from a pressurized aerosol. The changes in FEV_1 and SGaw after salbutamol in the normal subjects are shown in Table II. In six there was a small increase in FEV_1, ranging from 50 ml to 250 ml, while in four there was no change. The mean increase was only 90 ml, which is 2% of the mean baseline value, but this small increase is significant ($P<0.02$). In the same subjects an increase in SGaw ranging from 10 to 74% of the baseline value was seen. The mean increase in SGaw was 37% of the mean baseline value ($P<0.001$).

In the asthmatics (Table III) there was a substantial rise in FEV_1 in all patients after

TABLE II

CHANGES IN FEV_1 AND SGaw AFTER SALBUTAMOL IN NORMAL SUBJECTS

	FEV_1 (l. ATPS)				SGaw (ml/sec/cmH_2O/l.)			
	Salbutamol		Change		Salbutamol		Change	
Subject	Before	After	Litres	%	Before	After	(ml/sec/cmH_2O/l.)	%
1	4·15	4·30	+0·15	+4	172	274	+102	+59
2	4·40	4·40	0	0	283	312	+ 29	+10
3	3·75	4·00	+0·25	+7	178	309	+131	+74
4	4·90	5·05	+0·15	+3	212	356	+144	+68
5	4·90	4·95	+0·05	+1	242	338	+ 96	+40
6	4·45	4·55	+0·10	+2	132	146	+ 14	+11
7	3·70	3·85	+0·15	+4	153	210	+ 57	+37
8	5·10	5·10	0	0	122	142	+ 20	+16
9	4·60	4·60	0	0	208	302	+ 94	+45
10	4·35	4·35	0	0	188	203	+ 15	+ 8
Mean	4·43	4·52	+0·09[1]	+2	189	259	+ 70	+37[2]

[1] $P < 0.02$.
[2] $P < 0.001$.

TABLE III

CHANGES IN FEV_1 AND SGaw AFTER SALBUTAMOL IN ASTHMATICS

	FEV_1 (l. ATPS)				SGaw (ml/sec/cmH_2O/l.)			
	Salbutamol		Change		Salbutamol		Change	
Patient	Before	After	Litres	%	Before	After	ml/sec/cmH_2O/l.	%
1	0·75	1·15	+0·40	+53	8	24	+ 16	+200
2	1·55	1·85	+0·30	+19	29	43	+ 14	+ 48
3	2·40	2·85	+0·45	+19	35	66	+ 31	+ 89
4	1·40	1·80	+0·40	+29	30	34	+ 4	+ 13
5	1·45	2·00	+0·55	+38	26	91	+ 65	+250
6	1·25	1·75	+0·50	+40	62	80	+ 18	+ 29
7	1·55	1·95	+0·40	+26	29	85	+ 56	+193
8	1·65	1·85	+0·20	+12	86	189	+103	+120
9	0·70	1·35	+0·65	+93	5	26	+ 21	+420
10	0·75	1·20	+0·45	+60	18	50	+ 32	+178
Mean	1·35	1·78	+0·43	+32[1]	33	69	+ 36	+109[1]

[1] $P < 0.001$.

TABLE IV

CHANGES IN FEV_1 AND SGaw AFTER SALBUTAMOL IN BRONCHITICS

Patient	FEV_1 (l. ATPS)				SGaw (ml/sec/cmH_2O/l.)			
	Salbutamol		Change		Salbutamol		Change	
	Before	After	Litres	%	Before	After	ml/sec/cmH_2O/l.	%
1	1·00	0·90	−0·10	−10	35	34	− 1	− 3
2	0·35	0·45	+0·10	+29	17	25	+ 8	+ 47
3	1·15	1·25	+0·10	+ 9	38	53	+15	+ 39
4	0·90	1·05	+0·15	+17	65	108	+43	+ 66
5	0·55	0·70	+0·15	+27	14	17	+ 3	+ 21
6	1·15	1·35	+0·20	+17	21	28	+ 7	+ 33
7	1·15	1·25	+0·10	+ 9	42	51	+ 9	+ 21
8	0·75	0·85	+0·10	+13	24	29	+ 5	+ 21
9	0·40	0·55	+0·15	+38	8	16	+ 8	+100
10	1·00	1·05	+0·05	0	24	35	+11	+ 46
Mean	0·84	0·94	+0·10	+12[1]	29	40	+11	+ 38[2]

[1] $P < 0.01$.
[2] $P < 0.001$.

salbutamol. The mean increase was 430 ml, which is 32% above the mean baseline value ($P<0.001$). The mean increase in SGaw after salbutamol was 109% of the mean baseline value ($P<0.001$). In the bronchitics (Table IV), nine showed a small increase in FEV_1 after salbutamol, and in one patient there was a slight fall. The mean increase in FEV_1 was 100 ml, which was similar to that seen in the normal subjects. However, since the mean pre-salbutamol FEV_1 value was much lower in the bronchitics than in the normal subjects, this mean increase of 100 ml represents a larger percentage change of 12% ($P<0.01$). The mean increase in SGaw, on the other hand, was less than that seen in normal subjects, although the percentage change (38%) was essentially the same ($P<0.001$).

DISCUSSION

In the normal subjects, the bronchodilator effect of salbutamol is clearly shown by the substantial rise in SGaw. By comparison, the mean increase in FEV_1, although statistically significant, was small, and this was also the case for the $FEV_{0.5}$ and $FEV_{0.75}$. A similar disparity between the increase in FEV_1 and SGaw following bronchodilator drugs in normals has been reported by McFadden, Newton-Howes, and Pride (1970) and by Bouhuys and van de Woestijne (1971). The former workers thought that this was largely due to their finding that the elastic recoil pressure of the lung, and hence the effective driving force for maximal expiratory air flow, was temporarily reduced after the bronchodilator. However, they used doses of isoprenaline much in excess of those commonly given therapeutically and suggested that a similar reduction in elastic recoil pressure might not be found with more conventional doses. Bouhuys and van de Woestijne (1971) used smaller doses of the same drug. They found no change in elastic recoil pressure and proposed a simpler explanation for the disparity between the two methods in detecting changes in airways calibre. They suggested that reduction in bronchial smooth muscle tone due to the drug leads not only to increased airways calibre, but also to increased airways collapsibility on expiration. Increased airways calibre results in increased specific conductance, but increased collapsibility limits the increase in air flow during forced expiration and so limits the rise in FEV_1 which might be expected to result from the increase in bronchial calibre.

If the hypothesis of Bouhuys and van de Woestijne (1971) be accepted, the large increases in both SGaw and FEV_1 after salbutamol in our asthmatics reflect the substantial degree of bronchodilatation which is only partially offset by increased airways collapsibility. In the bronchitics, on the other hand, while the increase in FEV_1 was proportionately greater than in normals, the mean increase in SGaw was no greater than that seen in normals. This last finding differs from that of Astin (1972), who showed a greater increase in SGaw in bronchitics than in normals after inhalation of isoprenaline. He used a much larger dose of bronchodilator than we did—6 mg of isoprenaline compared with 200 μg of salbutamol used in this study—and this difference in dosage may well account for the effect he observed.

The results of this study suggest that in normal subjects SGaw is more sensitive than FEV_1 in detecting the effects of a bronchodilator drug on bronchial calibre. However, in patients with airways obstruction the more easily measured

FEV_1 is as good an indicator of changes in airway calibre following bronchodilators as the SGaw. This latter measurement requires much more expensive equipment than is needed for the FEV_1.

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