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 (FEV₁) 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 FEV₁ increased by 2% in normals, by 32% in asthmatics, and by 12% in obstructive bronchitics. SGaw appears to be a more sensitive indicator than FEV₁ of changes in airways calibre following a bronchodilator drug in normal subjects, but FEV₁ 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 (FEV₁). However, bronchial calibre is only one of several factors which determine the FEV₁ (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 FEV₁ (Lloyd and Wright, 1963; Feinsilver, 1966; Cohen, 1969).

The aim of the present study is to compare changes in FEV₁ 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 FEV₁ 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 FEV₁ and SGaw were both reduced at

TABLE I
DETAILS OF SUBJECTS STUDIED

	No.	Sex	Mean Age (yr)	Mean FEV ₁ (l. ATFS)	Mean SGaw (ml/sec/cmH ₂ O/l.) ¹
Normal	10	M	24	4.43	189
Asthmatic	10	7M 3F	34	1.35	33
Bronchitic	10	M	62	0.84	29

¹Normal range for SGaw 114–414 ml/sec/cmH₂O/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 FEV₁ and SGaw were reduced.

Forced expiratory spirometers were obtained with a dry-wedge spirometer and from the best of three attempts the FEV₁ 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 ($1/\text{Raw} \times \text{TGV}$). 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 FEV₁ and SGaw after salbutamol in the normal subjects are shown in Table II. In six there was a small increase in FEV₁, 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 FEV₁ in all patients after

TABLE II
CHANGES IN FEV₁ AND SGaw AFTER SALBUTAMOL IN NORMAL SUBJECTS

Subject	FEV ₁ (l. APTS)				SGaw (ml/sec/cmH ₂ O/l.)			
	Salbutamol		Change		Salbutamol		Change	
	Before	After	Litres	%	Before	After	(ml/sec/ cmH ₂ O/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

¹P < 0.02.

²P < 0.001.

TABLE III
CHANGES IN FEV₁ AND SGaw AFTER SALBUTAMOL IN ASTHMATICS

Patient	FEV ₁ (l. APTS)				SGaw (ml/sec/cmH ₂ O/l.)			
	Salbutamol		Change		Salbutamol		Change	
	Before	After	Litres	%	Before	After	(ml/sec/ cmH ₂ O/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	29	80	+ 51	+173
7	1.55	1.95	+0.40	+26	62	85	+ 23	+ 37
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

¹P < 0.001.

TABLE IV
CHANGES IN FEV₁ AND SGaw AFTER SALBUTAMOL IN BRONCHITICS

Patient	FEV ₁ (l. ATPS)				SGaw (ml/sec/cmH ₂ O/l.)			
	Salbutamol		Change		Salbutamol		Change	
	Before	After	Litres	%	Before	After	ml/sec/ cmH ₂ O/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

¹P < 0.01.²P < 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 FEV₁ after salbutamol, and in one patient there was a slight fall. The mean increase in FEV₁ was 100 ml, which was similar to that seen in the normal subjects. However, since the mean pre-salbutamol FEV₁ 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 FEV₁, 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 FEV₁ 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 FEV₁ 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 FEV₁ after salbutamol in our asthmatics reflect the substantial degree of bronchodilation which is only partially offset by increased airways collapsibility. In the bronchitics on the other hand, while the increase in FEV₁ 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 FEV₁ in detecting the effects of a bronchodilator drug on bronchial calibre. However, in patients with airways obstruction the more easily measured

FEV₁ 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 FEV₁.

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REFERENCES

- Astin, T. W. (1972). Reversibility of airways obstruction in chronic bronchitis. *Clinical Science*, **42**, 725.
- Bouhuys, A. and van de Woestijne, K. P. (1971). Mechanical consequences of airway smooth muscle relaxation. *Journal of Applied Physiology*, **30**, 670.
- Cohen, B. M. (1969). Airways flow resistance as a measure of the efficiency of inhalants in clinical drug trials. *Helvetica Medica Acta*, **34**, 455.
- Feinsilver, O. (1966). Airway resistance as an index of effectiveness of bronchodilating drugs. *Journal of Allergy*, **38**, 195.
- Guyatt, A. R. and Alpers, J. H. (1968). Factors affecting airways conductance: a study of 752 working men. *Journal of Applied Physiology*, **24**, 310.
- Lloyd, T. C. and Wright, G. W. (1963). Evaluation of methods used in detecting changes of airway resistance in man. *American Review of Respiratory Diseases*, **87**, 529.
- McFadden, E. R., Newton-Howes, J., and Pride, N. B. (1970). Acute effects of inhaled isoproterenol on the mechanical characteristics of the lungs in normal man. *Journal of Clinical Investigation*, **49**, 779.
- Pride, N. B. (1971). The assessment of airflow obstruction: role of measurements of airways resistance and of tests of forced expiration. *British Journal of Diseases of the Chest*, **65**, 135.

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