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Differentiation between localized and generalized airway obstruction

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Before operating on patients with lung tumours, we often need to know whether their air flow obstruction is caused entirely by the local tumour or whether there is generalized obstruction from bronchitis or emphysema as well. In the former case, the post-operative period may be expected to be uneventful, since the cause of the obstruction, the tumour, is removed. In the latter, special measures have to be taken to meet with post-operative breathing difficulties.

This paper presents a study of dynamic ventilatory capacities and distribution of air in the lungs, measured with single-breath tests in patients with bronchial and tracheal tumours. The size of the tumour was observed by bronchoscopy and radiography; several specimens were also examined after resection.

MATERIAL

Nineteen patients, all with bronchial or tracheal tumours, were divided into two groups. Group 1 comprised patients without persisting signs or history of bronchitis or airways obstruction, namely, (*a*) two patients with tracheal stenosis; and (*b*) six men and two women, aged 18 to 69 years, with tumours in the central airways, usually the main bronchus (Table I). Group 2 consisted of patients with a history of chronic non-specific broncho-pulmonary disease, many of whom had smoked for several years and were breathless. There were nine men aged 37 to 77 years (Table II).

We thought at bronchoscopy that air could pass the tumour in all these patients.

METHOD AND CLASSIFICATION

The spirometry was performed with low flow-resistance spirometers built according to Bernstein, D'Silva, and Mendel (1952). The volumes obtained were compared with normal values from this laboratory (Berglund, Birath, Bjure, Grimby, Kjellmer, Sandqvist, and Söderholm, 1963). The patients were considered *obstructive* when the $F.E.V._{1.0}$[1] and F.E.V.% were less than the normal predicted minus two standard deviations (S.D.). If the $F.E.V._{1.0}$ and the F.V.C. were less than normal minus two S.D. but the F.E.V.% was normal, the subjects were classified as *restrictive*.

The distribution of air in the lungs was evaluated with four to five single-breath N_2-curves, in which the 'alveolar' nitrogen gradient was obtained with a method already described in detail (Kjellmer, Sandqvist, and Berglund, 1959). The result was considered pathological when the mean N_2-gradient between the expired volumes 750 and 1,250 ml. was equal to or higher than the upper 95% confidence limit in normal material from this laboratory (Sandqvist and Kjellmer, 1960).

RESULTS

Both subjects with tracheal stenosis were severely obstructive on expiration (Table I). In subject J. J., figures obtained with forced inspiration showed an even more severe inspiratory obstruction, the F.E.V./F.I.V. ratio being 1·41. In spite of this extensive obstruction, the single-breath N_2 was normal.

In the eight patients in group 1b, six of whom had narrowing of one main bronchus, six patients were obstructive and two were restrictive (Table I). The N_2-gradient was below the upper 95% confidence limit in all. The difference between the pairs of measured mean values and the individual predicted upper limits was significant ($P<0.001$).

[1] Nomenclature according to Gandevia and Hugh-Jones (1957)

TABLE I

VENTILATORY CAPACITIES AND GAS DISTRIBUTION IN THE LUNGS OF PATIENTS WITH BRONCHIAL TUMOURS BUT WITHOUT CHRONIC RESPIRATORY DISEASE

Subject	Sex	Age	Bronchoscopic Findings	Forced Expirograms						Distribution	
				F.E.V.$_{1.0}$		F.V.C.		F.E.V.%		N_2–Gradient (%)	Predicted + 2 S.D.
				Litres	% Predicted	Litres	% Predicted	%	Predicted −2 S.D.		
a. Tracheal Stenosis											
A.S.	F	52	Luetic aneurysm, lumen < 1 cm. ..	0·56	23	2·81	88	41	64	1·7	4·7
J.J.	M	13	Thymoma, lumen 50% of normal*	1·28	51	2·38	79	54	74	1·7	2·0
b. Tumours Mainly in Main Bronchus											
A.S.	F	69	Adenoma left main bronchus size of a cherry	1·47	70	3·19	114	47	63	3·4	5·5
M.T.	F	18	Stenosis after resection adenoma left main bronchus	1·53	46	2·14	56	71	76	2·7	2·8
Y.N.	M	63	Nearly occluded left main bronchus ..	1·79	64	3·95	94	45	54	2·7	5·4
V.A.	M	69	Nearly occluded right main bronchus; atelectasis of upper lobe ..	1·46	52	3·15	67	49	52	3·2	5·8
G.P.	M	60	Tumour bulges into right lower lobe; middle lobe bronchus partly occluded ..	1·63	50	3·52	78	49	55	5·1	5·1
E.S.	M	63	Partial occlusion of left main bronchus ..	2·20	69	4·04	87	58	54	3·1	5·8
H.Ö.	M	60	Narrowing of left upper lobe; narrowing of lower trachea ..	2·02	67	3·17	68	64	55	2·9	5·3
T.G.	M	52	Cauliflower-like tumour partially occluding right main bronchus ..	2·22	65	3·26	63	68	58	2·8	4·4
Mean values :	F	46									
	M	54		1·62	56	3·16	79	55	61	2·9	4·7

*F.I.V.$_{1.0}$ = 0·91 ; F.I.V.C. = 1·85 ; F.I.V.% = 50

In group 2, seven of nine subjects had an N_2-gradient higher than the upper 95% confidence limit. The difference between the predicted upper limit and the actual gradient was significant ($P<0.05$). Five patients were obstructive; the remaining four were restrictive (Table II).

DISCUSSION

In most subjects with generalized airway obstruction the N_2-gradient is large and the F.E.V.% is low. In some cases with slight obstruction only, the N_2-gradient is pathological (Malmberg, Simonsson, and Berglund, 1963).

In subjects with only localized obstruction, a pathological F.E.V.% is often obtained together with a normal N_2-gradient. The most extreme obstructive spirometric pattern is an amputation of the V.C. which creates the picture of a 'restrictive' ventilatory impairment. The tumour conceivably occludes the airway totally in some phase of the expiration, when the airway is compressed due to a fall in the intraluminal pressure behind the narrowing point. The V.C. thus might become more impeded than the F.E.V.$_{1.0}$ which renders the F.E.V.% normal.

A narrowed central airway does not seem to create an obvious asynchronous emptying of the gas from the lungs. There are reasons to believe that a central obstruction might even make the emptying of peripheral parts more equal due to pressure dilatation of narrowed airways (*cf.* 'pursed lips breathing').

In patients with widespread bronchitis or emphysema, different time constants throughout the lungs give an asynchronous emptying (Otis, McKerrow, Bartlett, Mead, McIlroy, Silverstone, and Radford, 1956). With the addition of a local tumour in the central airways, a large pre-existing N_2-gradient still persists. The single-breath nitrogen test thus can be used to assess the nature of airway obstruction in patients with bronchial tumours. If there is a pathological N_2-gradient, there is reason to assume the presence of generalized airways obstruction.

TABLE II

VENTILATORY CAPACITIES AND GAS DISTRIBUTION IN THE LUNGS OF PATIENTS WITH BOTH BRONCHIAL TUMOURS AND CHRONIC RESPIRATORY DISEASE

Subject	Sex	Age	Bronchoscopic Findings	Forced Expirograms						Distribution	
				F.E.V.$_{1\cdot0}$		F.V.C.		F.E.V.%		N_2-Gradient (%)	Predicted + 2 S.D.
				Litres	% Predicted	Litres	% Predicted	%	Predicted −2 S.D		
A.G.	M	61	Bronchitis ; narrowed left lower lobe and lingula	1·06	38	3·42	86	31	55	5·0	5·2
R.S.	M	58	Bronchitis ; narrowing of right upper lobe bronchus	1·28	39	3·62	76	35	56	6·7	5·1
K.G.	M	64	Bronchitis ; narrowing of right upper lobe bronchus	0·80	28	2·07	47	39	54	9·4	5·3
A.G.	M	37	Bronchitis ; adenoma almost occluding left main bronchus	2·22	56	3·42	62	65	64	5·4	3·6
A.S.	M	50	Bronchitis ; polypoid tumour oscillating in right main bronchus	2·70	82	4·61	93	61	58	7·4	4·6
J.K.	M	60	Bronchitis ; almost occluded right main bronchus*; emphysema	1·58	54	2·65	62	60	55	5·7	5·2
C.B.	M	67	Bronchitis : round tumour narrowing right main bronchus	1·78	62	3·00	68	65	53	4·7	5·6
V.T.	M	77	Bronchitis ; partial occlusion of br. 1 and 2 right upper lobe	1·85	77	2·75	71	67	49	7·0	5·8
T.A.	M	61	Tuberculosis, bronchitis; narrowed right upper lobe bronchus; swollen lower bronchus	1·65	69	2·13	60	77	55	5·8	5·2
Mean values		59		1·65	56	3·07	69	56	55	6·3	5·1

*Pathological anatomical diagnosis

TABLE III

VENTILATORY PARAMETERS AND DISTRIBUTION IN DIFFERENT BRONCHIAL CONDITIONS

Bronchial Condition	Forced Expirograms			Forced Inspirograms			N_2-Gradient
	F.E.V.$_{1\cdot0}$	F.V.C.	F.E.V.%	F.I.V.$_{1\cdot0}$	F.I.V.C.	F.I.V.%	
Tracheal stenosis	Lowered	Lowered	Lowered	Increased F.E.V. > F.I.V.	Lowered	Lowered	Normal
Tumour in main bronchus	Lowered	Lowered	Lowered (normal)	Increased F.I.V. > F.E.V.	Lowered		Normal
Generalized airways obstruction + central tumour	Lowered	Lowered	Lowered	F.I.V. > F.E.V.			Pathological

As a further means of differentiation between localized and generalized obstruction, bronchodilating drugs could be tried. Irreversibility of a short-lasting obstruction points to a localized hindrance to airflow.

SUMMARY AND CONCLUSION

Dynamic ventilatory capacities and the single-breath nitrogen test of asynchronous pulmonary ventilation were compared in patients with bronchoscopically observed narrowing due to tracheal or bronchial tumours.

In two subjects with tracheal stenosis the expiratory and inspiratory obstruction was severe, but the N_2-test was still normal. In eight other patients without an earlier history of bronchitis or emphysema, the obstructive spirometry was not combined with a pathological distribution.

In nine patients with tumours *and* a history of

chronic bronchitis or emphysema, the obstructive or restrictive ventilatory capacity co-existed with definitely asynchronous gas distribution.

The N_2-test combined with spirometry is of value in differentiating between generalized and localized airway obstruction.

REFERENCES

Bernstein, L., D'Silva, J. L., and Mendel, D. (1952). The effect of the rate of breathing on the maximum breathing capacity determined with a new spirometer. *Thorax*, **7**, 255.

Berglund, E., Birath, G., Bjure, J., Grimby, G., Kjellmer, I., Sandqvist, L., and Söderholm, B. (1963). Spirometric studies in normal subjects. I. Forced expirograms in subjects between 7 and 70 years of age. *Acta med. scand.*, **183**, 185.

Gandevia, B., and Hugh-Jones, P. (1957). Terminology for measurements of ventilatory capacity. *Thorax*, **12**, 290.

Kjellmer, I., Sandqvist, L., and Berglund, E. (1959). "Alveolar plateau" of the single breath nitrogen elimination curve in normal subjects. *J. appl. Physiol.*, **14**, 105.

Malmberg, R., Simonsson, B., and Berglund, E. (1963). Airways obstruction and uneven gas distribution in the lung. *Thorax*, **18**, 168.

Otis, A. B., McKerrow, C. B., Bartlett, R. A., Mead, J., McIlroy, M. B., Selverstone, N. J., and Radford, E. P. (1956). Mechanical factors in distribution of pulmonary ventilation. *J. appl. Physiol.*, **8**, 427.

Sandqvist, L., and Kjellmer, I. (1960). Normal values for the single breath nitrogen elimination test in different age groups. *Scand. J. clin. Lab. Invest.*, **12**, 131.