A COMPARATIVE STUDY OF A FEW TESTS OF DYNAMIC LUNG FUNCTION

B.N. Mazumdar, C.A. Desai and N.C. Shah
Medical College, Baroda

Summary: A variety of tests like $FEV_{0.75}$, FEV_1, PFR, MEFR is in use for assessment of ventilatory function of the lungs. Each of them has some marginal advantage over the other. It is, therefore, necessary to find out their relative merits and choose the one which can provide the maximum information in a reasonably short time. In this project, a norm of all the above tests for the people of Gujarat of age group 18-20 years has been found, the relative merit of the tests has been discussed and the velocity of air flow at 0.3 sec of expiration has been suggested as the single measurement which may conveniently replace all the other above.

Key words: forced expiratory volume; peak flow rate; timed vital capacity; maximum mid-expiratory flow rate; lung function test

INTRODUCTION

Measurement of lung volumes as a function of time is more informative than that of static lung volumes. Thus, recording of timed vital capacity (FEV_t) peak flow rate (PFR), maximum expiratory flow rate (MEFR), and maximum mid-expiratory flow rate (MMEF) have come into use, in place of simple vital capacity to detect, differentiate and guage the degree of functional deficit in certain types of lesions affecting ventilatory function of the lungs. Again, in most of the obstructive diseases, the distal airways are affected influencing the air flow in small tubes with minor resistance and therefore FEV_t or MEFR may not be affected adversely. So, it is not only the maximum flow that is important, but the particular time, during which that maximum flow occurs is also important. No work seems to have been done to correlate these two parameters to evaluate the ventilatory functions of the lungs in health and relevant respiratory diseases.

In this project, the maximum velocity of air flow has been studied in terms of the time of expiration and the percentage of the volume expired. Also, the former has been compared with the FEV_t, PFR, MEFR and MMEF in normal healthy adults.

MATERIALS AND METHODS

Seventy healthy male students of Medical College, Baroda, Gujarat were included in the study. They were all non-smokers and in the age group of 18-20 years. They were clinically examined to exclude any abnormal finding. They appeared in the laboratory at 10.00 a.m. after having taken a light breakfast two hours earlier. The experiments were carried out at 27°C and 758 mm of Hg atmospheric pressure. Before the test, the details of the experiments were explained to the subjects, so that they tried to improve their performance. Their forced vital capacity (FVC) as suggested by Campbell (3), in standing posture was recorded on a fast moving smoked paper on a kymograph moving at a speed of 9.2 cm per sec. Benedict Roth closed circuit spirometer was used for the purpose. The best of the three performances was kept on record. After fixation of the record, calculations were made both for FEV_t and velocity of flow at 0.25, 0.30, 0.50, 0.75 and 1.00 sec of expiration. The FVC, PFR, total duration of expiration, MEFR and MMEF were also found out from the record. Maximum expiratory flow rate (MEFR) was calculated for one liter expired after initial 200 *ml* and expressed in liters per sec. Maximum mid-expiratory flow (MMEF) was calculated from average velocity of the air expired during middle half of the expiration.

Velocity of flow was calculated by drawing a tangent on the expiratory record at various timings from the beginning. The peak flow rate was read from the graph showing the velocity against time (Fig. 2).

RESULTS AND DISCUSSION

Subjects had been divided into five groups on the basis of body surface area (Table I). In this study, the average vital capacity in 70 healthy students was found to be 3.05 ± 0.12 liters (Table II). Telang, in his study of a similar age group from Bombay, had reported a vital capacity of 3.08 liters (9). Other workers had also found vital capacity very close to this figure (6). Though the average FEV_3 is recorded as 97% in normal adults (7), in our study, the total time of forced expiration lasted for 2.2 seconds (Table II), so, there was no question

TABLE I: Grouping of the subjects on the basis of average body surface area in sq. m. (BSA). Figures in paranthesis indicate range of surface area. Av.=Average.

Group	*I*	*II*	*III*	*IV*	*V*
BSA	1.37 (1.30-1.39)	1.43 (1.40-1.49)	1.54 (1.50-1.59)	1.63 (1.60-1.69)	1.73 (1.70-1.79)
Number of subjects	12	14	17	13	14
Av. height in cm.	156.0	160.1	160.5	169.0	174.4

TABLE II: Result of lung function tests in different groups. Expiration (Exp.) time is expressed in sec and vital capacity (V.C.) in liters. Average peak flow (PFR), maximum expiratory flow (MEFR) and maximum mid-expiratory flow (MMEF) are expressed in liters per second. Av. = Average.

Groups	*I*	*II*	*III*	*IV*	*V*	*Mean*	*S.E.±*
Predicted V.C.	2.87	3.05	3.35	3.59	3.89	3.35	—
Av. Exp. time	2.20	2.30	2.30	2.00	2.30	2.22	0.06
Av. V.C.	3.90	2.77	2.99	3.16	3.44	3.05	0.12
Av. PFR	3.90	3.65	3.84	4.00	3.92	3.86	0.08
Av. MEFR	3.23	3.31	3.62	4.11	3.92	3.64	0.17
Av. MMEF	1.50	1.20	1.30	1.20	1.30	1.32	0.06

of FEV_3. Kasliwal had reported vital capacity with total expiration time of less than three seconds (5). Eventually, therefore, the percentage of the total volume expelled in different periods of expiration and as such $FEV_{0.75}$ or FEV_1 as recorded in the text books have to be modified. Our records showed FEV_1 as 88.25% as against 85% of forced vital capacity found by Shah (8). This gave an average velocity of 2.66 l/sec during the first second of expiration, which, of course was not uniform but relatively fast between 0.25 sec and 0.50 sec and slow on either side of it (Fig. 2). Thus during first 0.75 sec and 1 sec the average velocities were 3.00 and 2.66 l/sec. i.e., 22% and 30.5% less respectively than PFR, which was 3.86 ±0.06 liters per sec in our experiments and occured at 25% expiration (Fig. 1), i.e. at the expiratory volume of 0.76 liters and at 0.32 sec. from the begining of expiration (Fig. 2). Black *et al.* had also reported the maximum velocity of expired air at 25% of forced expiratory volume (2).

It is the practice to record the shortest FEVt, which includes the period of maximum velocity. So it will be worthwhile to find $FEV_{0.3}$ or better still, the air velocity of 0.3 sec of expiration instead of FEV_1. With this idea Comroe suggested recording of $FEV_{0.25-0.50}$ (4). Again, MEFR of 3.64±0.17 l/sec as found in our experiments included expiratory phase between 0.10 sec and 0.45 sec, which covered and thus supported the idea of recording of the air velocity at 0.3 sec. Bhargava reported it as 4 l/sec (1), under the term of MMEFR. Our result was near that. Not only this, but the PFR of 3.86±0.06 liters per sec found in our

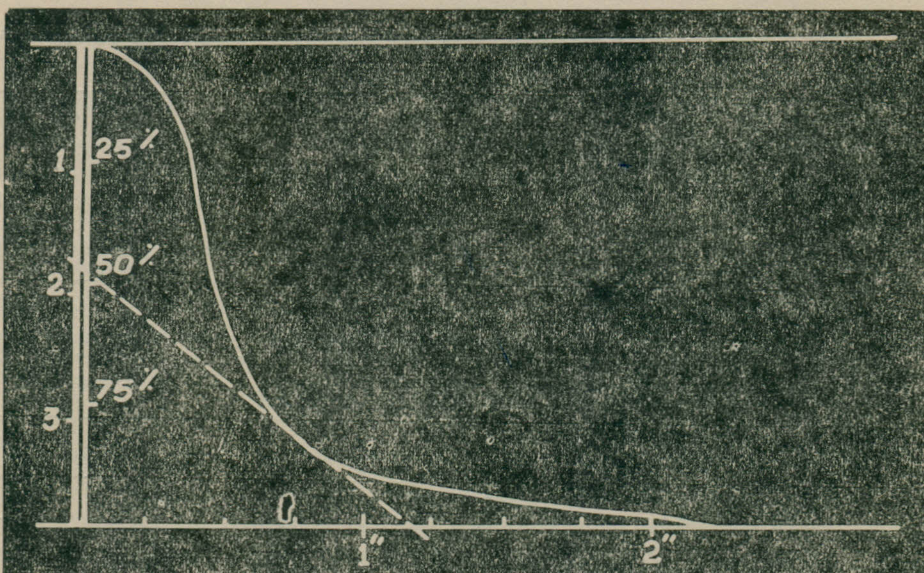

Fig. 1: Shows the calculation of velocity at a particular time during expiration. The outer ordinate represents the expiratory volume in liters, the inner ordinate represents the percentage of volume expired. The abscisa denotes the time in sec. The interrupted line is a tangent drawn on the expiratory record at 0.75 sec. This shows 1.75 lit. of air expired in 1.16 sec. i.e. the velocity = 1.5 lit. per sec.

cases at 0.32 sec also fell in this period (Fig. 2). Maximum mid-expiratory flow rate (MMEF), which fell between 0.55 sec and 1.65 sec of expiration had been found to be 1.32 l/sec. So it is suggested that only one figure, i.e. the velocity of air flow at 0.3 sec of expiration should provide sufficient information and that FEV_t, PFR, MEFR and MMEF may not furnish any additional useful information.

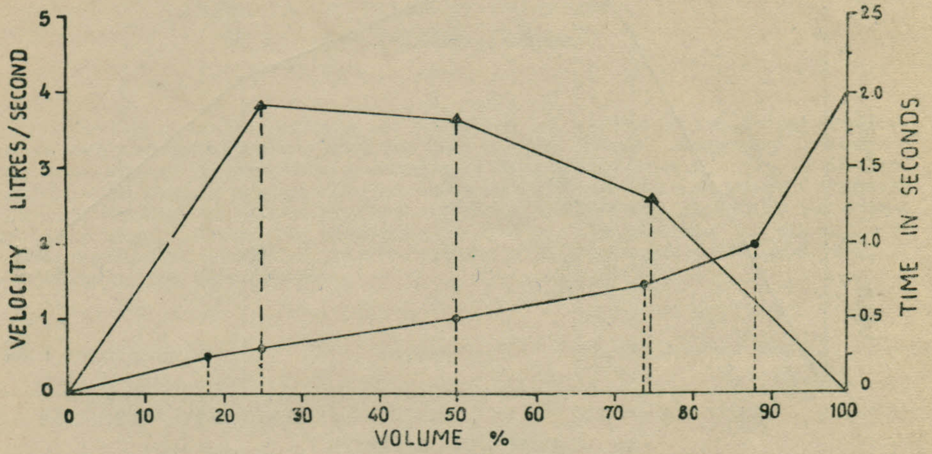

Fig. 2: Round dots show the percentage of volume of the air expired at various timings. The triangular spots show the velocity of air flow at various percentage of expired volume.

TABLE III: Velocity of flow of expired air at different intervals after the onset of expiration and at various percentage of expired volume.

	Average air velocity in l/sec							
	Time in sec after beginning of expiration					*Percentage of expired volume*		
Group	0.25	0.30	0.50	0.75	1.00	25	50	75
I	3.1	3.5	3.2	2.7	1.3	3.2	3.3	2.3
II	3.0	3.7	3.8	2.6	1.4	3.4	3.4	2.6
III	3.2	3.9	3.2	2.8	1.3	3.7	3.4	2.6
IV	3.4	3.9	3.3	2.9	1.3	4.4	3.9	2.9
V	1.4	3.5	4.0	3.7	1.4	4.7	4.6	2.8
Mean	3.2	3.8	3.2	2.8	1.3	3.8	3.7	2.6
S.E. ±	0.09	0.09	0.16	0.07	0.03	0.28	0.24	0.10

It is therefore concluded, that to diagnose a case of ventilatory defect of the lungs, one should first find out vital capacity. If it is less than 50% of the predicted vital capacity, one should find out the air velocity at 0.3 sec. after the on-set of expiration. A markedly low figure would suggest an obstructive type of defect, while a value in the normal range may suggest one of restrictive type. Ten cases of obstructive type of defect suffering from moderate degree of obstructive bronchitis studied in our laboratory showed an average velocity of 2 liters

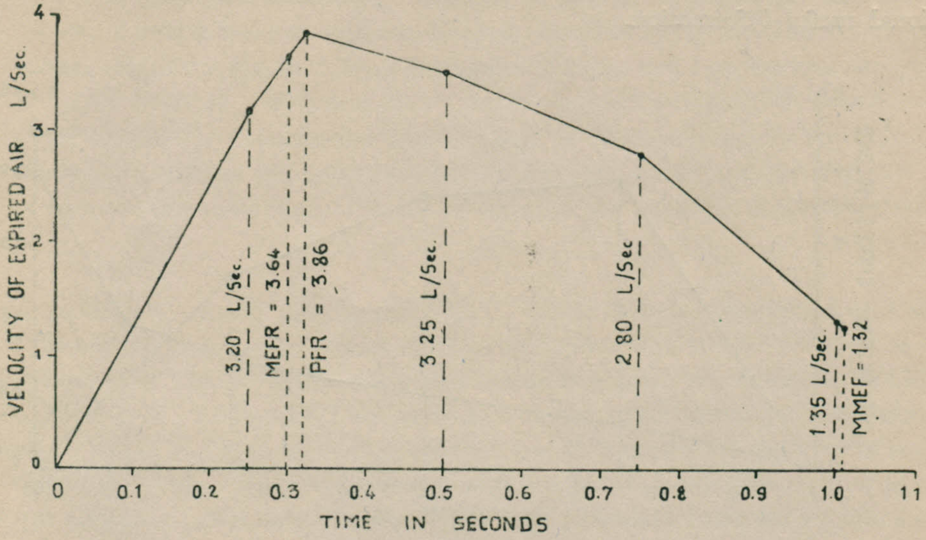

Fig. 3 : Shows the velocity of air flow at various times of expiration.

per sec at 0.3 sec of expiration. Ten cases with restrictive type of defect suffering from emphysema without obstruction showed an average velocity of 3.1 liters per sec at 0.3 sec. There is no doubt, that the number of clinical cases studied here were inadequate to give a firm opinion, nevertheless it supports our conclusion. In this context it is worthwhile to note, that Virgulto and Bouhuys suggested recording of a flow volume curve to distinguish an obstructive from a restrictive type of pulmonary lesion (10).

REFERENCES

1. Bhargava, R.P., S.M. Misra and N.K. Gupta. Ventilatory tests and lung volume studies in Madhya Pradesh — Physiological norms. *Ind. J. Physiol. Pharmac.,* **17** : 267-272, 1973.
2. Black, L.F., K. Offord and R.E. Hyatt. Variability in the maximum expiratory flow volume curve in asymptomatic smokers and in non-smokers. *Am. Rev. Resp. Dis.,* **110** : 282-292, 1974.
3. Campbell, E.J.M., C.J. Dickinson and J.D.H. Slater. Clinical Physiology. 3rd Ed. Oxford and Edinburgh. Blackwell Scientific Publications. p144, 1968.
4. Comroe, J.H., R.E. Foster, A.B. Dubois, W.A. Briscoe and E. Carlsen. The lung. 2nd Ed. Chicago. Year Book Med. Pub. Inc., p. 200, 1967.
5. Kasliwal, R.M., V.S. Baldwa and P.R. Sharma. Ventilatory tests and lung volume studies in health. *Journal I.M.A.,* **43** : 49-54, 1964.
6. Krishnan, B.T. and C. Vareed. Lung function. *Ind. J. Med. Res.,* **19** : 1165-1183, 1932.
7. Ruch, T.C. and H.D. Patton. Physiology and Biophysics. Asian Ed. 19th Ed. Philadelphia. W.B. Sanders p. 752, 1965.
8. Shah, J.R. Pulmonary function tests. Bombay. Worli printers, p.48, 1969.
9. Telang, D.M. and G.A. Bhagwat. Studies in the vital capacity of Bombay Medical students part-I statistics corrected with physical measurement. *Ind. J. Med. Res.,* **29** : 723-750, 1941.
10. Virgulto, J. and A. Bouhuys. Electronic circuits for recording of maximum expiratory flow volume (MEFV) curve, *J. Appl. Physiol.,* **35** : 145-147, 1973.