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The Comparison of Peak Flow Rate with Other Spirometric Measurements in Cyctic Fibrosis Patients*

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Chronic pulmonary disease dominates the clinical picture in cystic fibrosis patients and its severity determines the course of the disease.[1,2] Therefore, the value of frequent determinations of pulmonary functions in evaluating the prognosis of the patients, cannot be over-emphasized.

The pulmonary system findings in cystic fibrosis disease are mainly due to abnormal viscid and sticky secretions, which cause the obstruction of the airways.[3] Increased airway resistance due to obstruction results in an increased residual volume,[4,5] reduced vital capacity and flow rates[6] and also uneven ventilation.[7,8]

The measurement of airway resistance is one of the most useful pulmonary function tests. Although direct measurement of airway resistance is widely used in physiological studies, it is rarely performed in the clinical field.[9] Besides, most of these tests which are used for the evaluation of the pulmonary functions are time consuming, expensive and complicated.

In 1959 Wright and McKerrow[10] published the results of expiratory flow rates, measured by a simple and portable instrument which was called the Wright Peak Flowmeter. In later years many studies have been done in children and adults with this apparatus.[11-25]

The present study was done to determine the role of the peak flowmeter for evaluation of pulmonary functions in children with cystic fib-

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rosis. Forced expiratory volume in one second, maximal midexpiratory flow rate and maximal voluntary ventilation have been compared with peak flow rate. Since the peak flow rate appeared to be a more sensitive measurement for determining the effect of bronchodilating drugs,[24] and since there are different views on the effects of bronchodilators in cystic fibrosis patients,[5,26,28] measurements were repeated after administration of bronchodilating drugs.

Materials and Methods

This study was done on 55 children, 30 of whom were normal and 25 of whom had cystic fibrosis. The normal children were selected from among the children brought to the out-patient department with minor complaints and their physical and radiological examinations were within normal limits. The group of 25 children with cystic fibrosis were being followed in the Chest Department and diagnosis was established by family history, physical and radiological examinations and laboratory findings. In these children, chloride content in sweat was determined by pilocarpine iontophoresis technique,[29] and chloride in sweat above 60 mEq/l in more than one measurement was accepted as pathological.

Peak flow rate (PFR) was measured with a Wright peak flowmeter,* forced expiratory volume in one second (FEV_1), maximal midexpiratory flow rate (MMFR) and maximal voluntary ventilation (MVV) were measured with a low resistance spirometer** and the study was carried out according to the description of Kory and colleagues.[30]

To measure the peak flow rate, each child was asked to make a maximal inspiratory effort while the peak flowmeter was in his mouth, and expire into the instrument as hard and as fast as possible. Three attempts in succession were recorded, the highest value being taken for the statistical analysis.

Measurements were repeated after administration of bronchodilating drugs to patients. 0.5 cc Isuprel*** in 2 cc saline was administered by inhalation, with a Bennett**** type positive pressure respirator within 2-3 minutes. After inhalation the patients rested for five minutes and tests were then repeated. In this study standard statistical methods were used for the evaluation of the results.[31]

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* Airmed Ltd. Harlow, Essex, England.

** Warren E. Collins, Inc., Braintree, Massachusetts, U.S.A.

*** Isoproterenol hydrochloride: Winthrop Laboratories, New York, N. Y., U.S.A.

**** Bennett, Model TV2P: Bennett Respiration Products, Inc., Santa Monica, Calif., U.S.A.

Results

Correlation of lung function with age, weight, height and body surface areas in children has been investigated. In those studies, the best correlation was found to be between the height and the lung function.[4, 5, 11, 12, 32, 33] Sex difference in children revealed no effect on the measurement of FEV_1, MMFR, MVV and PFR.[11, 33-36] Thus, results in boys and girls have been evaluated together in this study.

Results of 30 normal children ranging from 5 to 16 years, and 25 children with cystic fibrosis disease ranging from 5 to 17 years in age, are shown in Table I and II, respectively.

TABLE I

VALUES OF FEV1, MMEFR, MVV AND PFR IN NORMAL CHILDREN

Boys	Age (yr)	Weight (kg)	Height (cm)	FEV_1 l	MMEFR l/min	MVV l/min	PFR l/min
	5	20	112	0.895	80	35	185
	7	22	125	1.620	125	68	225
	8	30	126	1.405	120	47	215
	8	32	130	1.760	133	75	240
	9	28	128	1.570	127	60	220
	9	31	136	1.765	142	59	300
	9	35	140	1.975	150	80	275
	10	32	136	1.700	120	71	255
	10	39	144	2.215	165	89	310
	11	36	143	2.005	140	76	300
	11	42	150	2.385	170	75	425
	12	46	155	2.510	180	95	395
	14	51	163	2.900	202	93	420
	14	56	167	3.060	207	98	500
	16	68	171	3.190	220	110	505
Girls							
	6	21	116	1.390	95	50	190
	7	24	119	1.300	100	38	200
	7	27	125	1.360	109	51	235
	8	27	129	1.460	124	57	225
	8	30	129	1.685	137	71	250
	8	29	132	1.500	120	55	290
	9	26	130	1.630	134	57	235
	9	31	135	1.590	130	72	250
	10	30	134	1.685	132	64	300
	10	30	135	1.700	128	75	245
	10	35	140	1.900	140	60	310
	12	40	152	2.200	164	86	305
	12	45	157	2.525	180	84	395
	13	42	155	2.300	165	87	415
	15	52	163	2.590	197	92	435

TABLE II

VALUES OF FEV_1, MMEFR, MVV AND PFR IN CYSTIC FIBROSIS CHILDREN BEFORE AND AFTER ADMINISTRATION OF BRONCHODILATING DRUG*

Boys			Before Bronchodilator				After Bronchodilator			
Age (yr)	Weight (kg)	Height (cm)	FEV_1 l	MMEFR l/min	MVV l/min	PFR l/min	FEV_1 l	MMEFR l/min	MVV l/min	PFR l/min
9	19	116	0.590	20	25	95	0 620	21	25	100
9	23	130	0.625	20	20	125	0 705	25	24	140
10	27	129	0.470	15	20	80	0.570	17	22	90
10	23	130	1.215	36	43	180	1.315	42	46	200
10	29	131	1.200	44	46	190	1.180	45	45	190
13	27	136	0.790	28	40	160	0.780	28	40	160
13	26	138	1.300	55	58	215	1.340	58	60	230
13	39	154	1.150	49	70	225	1.220	54	74	240
14	31	148	1.375	54	60	210	1.470	60	64	230
15	27	142	0.630	23	34	140	0.680	26	37	155
17	53	165	1.620	62	72	270	1.750	71	82	130
Girls										
5	16	102	0.610	20	21	70	0.670	23	21	80
8	18	118	0.900	44	30	150	0.960	49	32	165
8	21	122	0.995	35	39	160	1.010	35	37	155
9	20	128	0.700	22	26	135	0.780	26	28	150
9	24	132	0.790	27	32	140	0.810	29	33	140
10	23	129	0.800	26	31	165	0.835	29	34	165
11	24	132	1.245	38	48	200	1.340	44	52	220
13	27	137	0.970	31	36	140	0.980	31	34	135
13	30	140	0.870	20	45	150	0.900	22	47	160
13	25	143	1.100	36	40	190	1.210	40	43	210
13	40	154	1.130	32	40	205	1.190	40	42	210
14	30	133	1.115	39	56	170	1.205	44	54	190
14	58	158	1.650	55	60	275	1.760	61	65	295
16	38	156	1.180	45	55	180	1.155	44	56	185

* No statistically significant correlation was found ($P>0.4$)

The comparison of forced expiratory volume revealed a decrease of this measurement in cystic fibrosis patients. The mean value of this measurement in the sick patients was 52 % of the mean value of measurements in normal children. Maximal midexpiratory flow rate revealed the lowest values in patients. The mean value of this measurement was 24 % of the mean value of control groups. The mean value of maximal voluntary ventilation in children with cystic fibrosis disease was also reduced to 59 % of the mean value of the controls. Values of peak flow rate, measured by the Wright peak flowmeter was found low in patients and their mean values were 56 % of the normal children.

The mean values of FEV_1, MMFR, MVV and PFR obtained from healthy and cystic fibrosis children are shown together in Table III.

TABLE III

COMPARISON OF MEAN VALUES OF FEV_1, MMEFR, MVV AND PER IN 30 NORMAL CHILDREN AND 25 CYSTIC FIBROSIS PATIENTS

		Mean	S. Deviation	t	P
FEV_1	N	1.925	0.545		
l	P	1.001	0.310	7.41	<0.001
MMEFR	N	144.53	33.58		
l/min	P	33.32	13.06	15.04	<0.001
MVV	N	71.0	18.05		
l/min	P	41.88	14.77	5.60	<0.001
PFR	N	301.67	90.32		
l/min	P	168 58	49.58	6.45	<0.001

N= Normal Controls
P= Patients

Comparisons were done in order to establish the relationship between PFR and the other three spirometric measurements; these comparisons are shown in Figures 1, 2 and 3 separately. Correlation co-efficients for these comparisons were calculated to be high. Regression lines obtained by equation were also drawn.

Mean values of measurements after admininstration of bronchodilating drugs to children with cystic fibrosis revealed five and nine per per cent increase and this was found statistically nonsignificant ($P>0.4$).

Discussion

Differences were found statistically significant between the mean values of measurements obtained from healthy and sick children ($P < 0.001$). Besides this, comparison of spirometric measurements with peak flow rate resulted in a high degree of correlation.

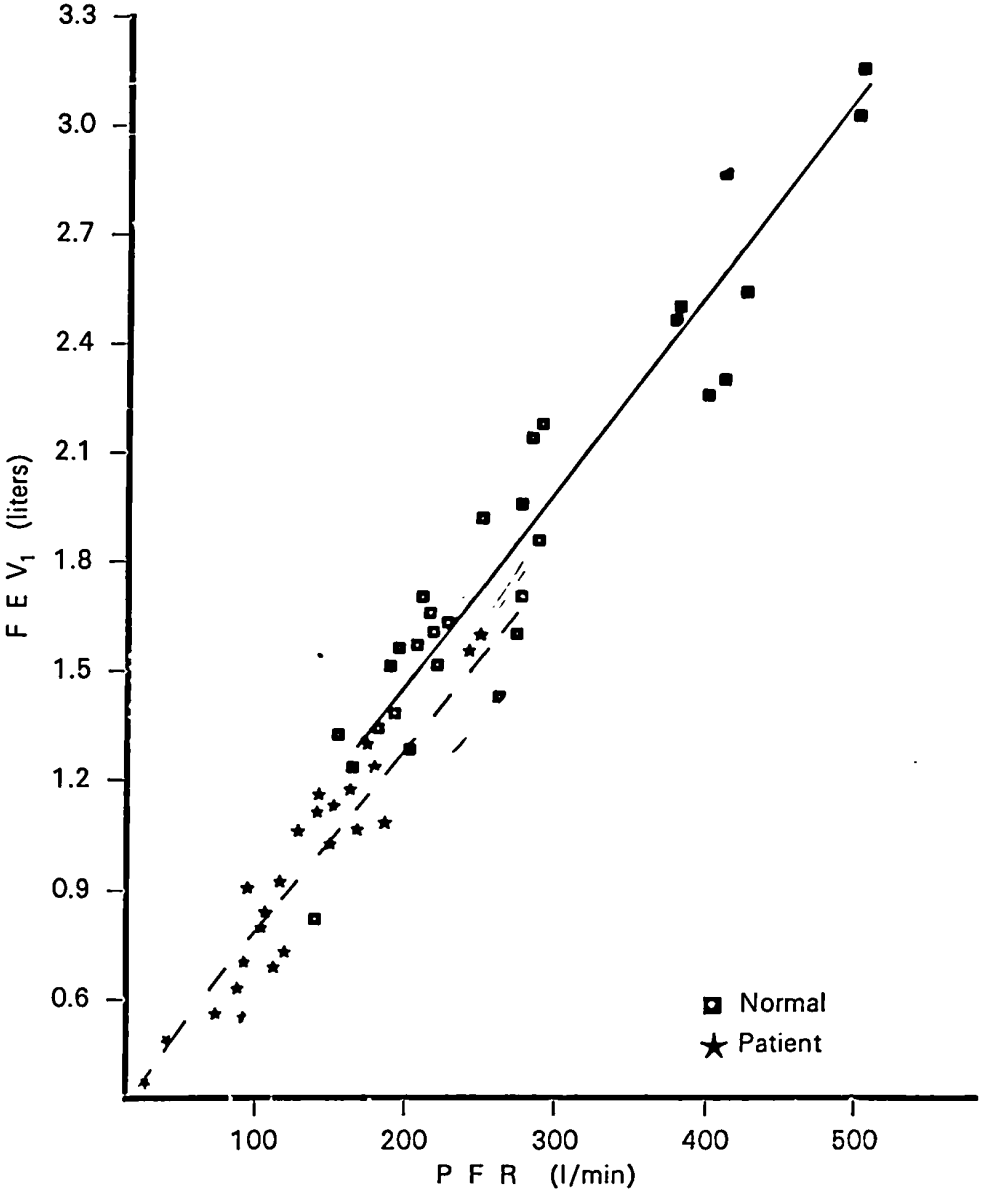

Figure 1

Comparison of forced expiratory volume in one second with peak flow rate in normal and sick children. The regression lines for normal children (——), and sick children (– – –), are shown.

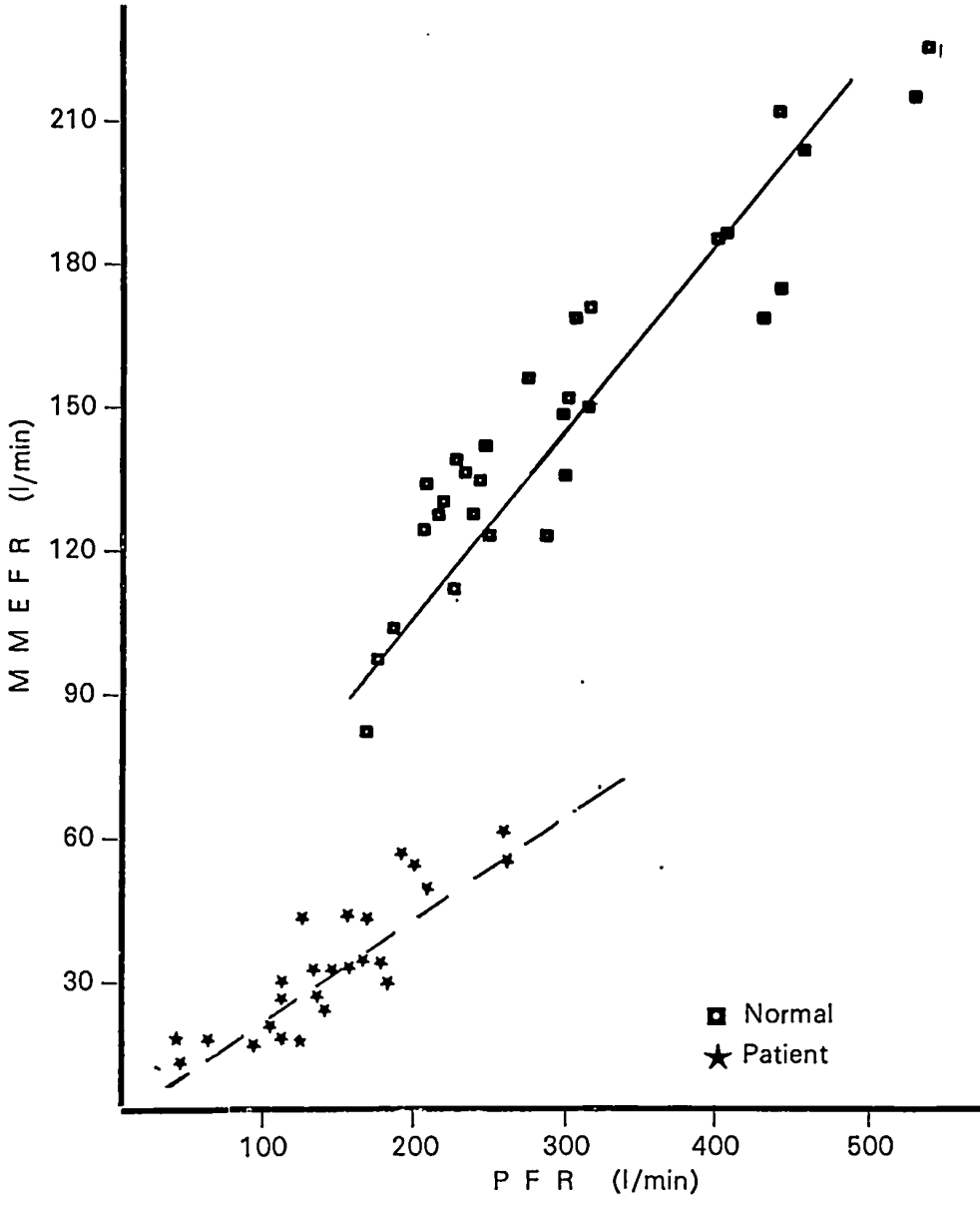

Figure 2

Comparison of maximal midexpiratory flow rate with peak flow rate in normal and sick children. The regression lines for normal children (———), and sick children (– – –), are shown.

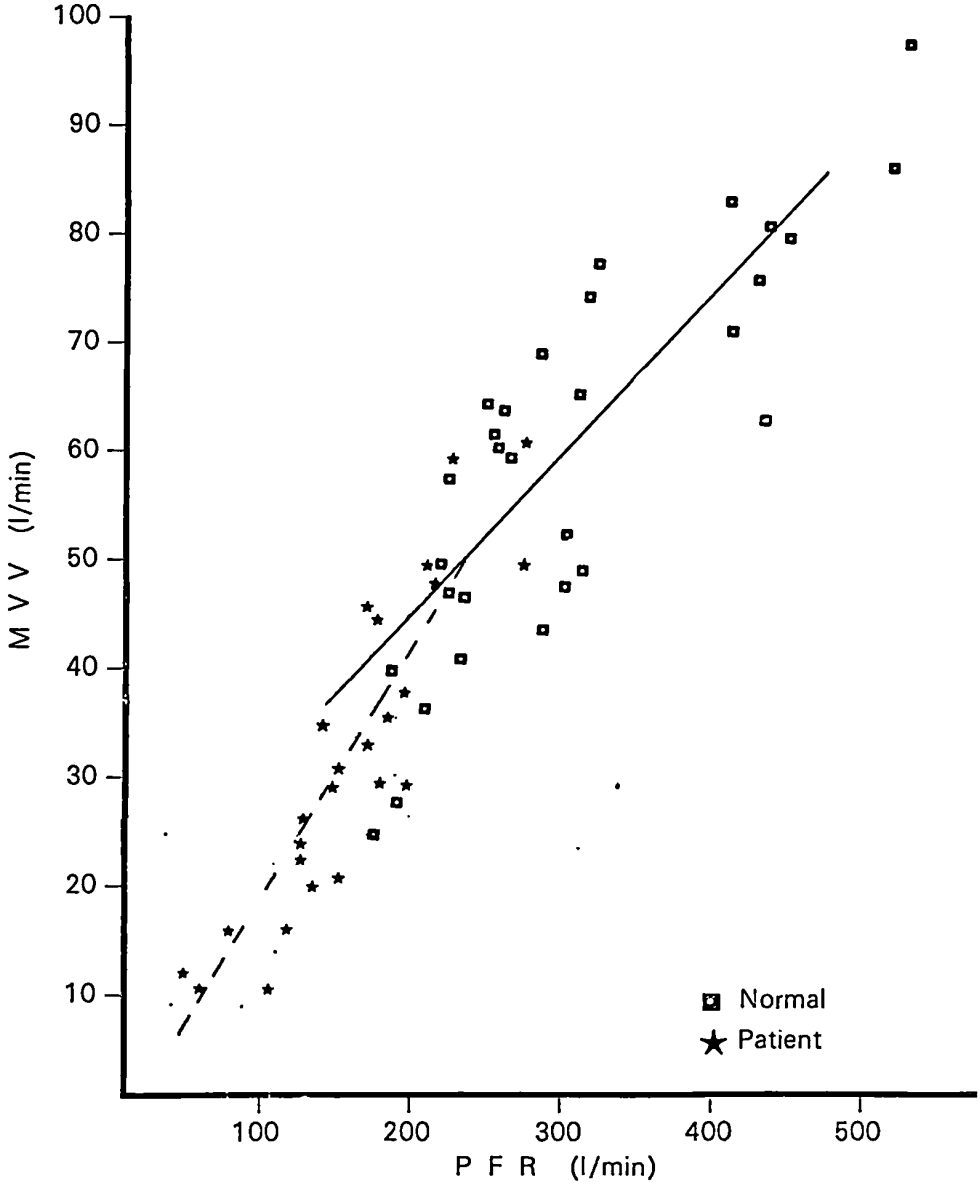

Figure 3

Comparison of maximal voluntary ventilation with peak flow rate in normal and sick children. The regression lines for normal children (———), and sick children (– – –), are shown.

In children with obstructive pulmonary disease, if some airways are completely obstructed vital capacity (VC) will be decreased, if airways are partially obstructed but are able to empty with a slow exhalation, vital capacity will be normal and in some asthmatics, vital capacity will be greater than normal. However, timed vital capacity (FEV_1) will always be decreased if obstruction exists.[37] This fact was observed in our study too.

In this study calculated correlation co-efficients between the PFR and FEV_1, was 0.948 in the normal children and 0.936 in cystic fibrosis patients. Furthermore, other studies which have been done in different pulmonary diseases other than cystic fibrosis also revelaled high degrees of correlation between the peak flow rate and timed vital capacity. Rosenblatt et al[23] demonstrated a correlation co-efficient of 0.85 in normal children and patients. Ritchie[24] showed a correlation co-efficient of 0.82 in patients. Heaf and Gillam[13] calculated a correlation co-efficient of 0.83 in normal children and 0.96 in patients. Dentry[38] also showed high degrees of correlation between the same variables.

Patients with airway obstruction can produce high flow rates at the beginning of the expiration but they can not continue during the main part of it. Valuable information has been obtained with evaluation of the mid-portion of the forced expiratory curve.[40] In our study, measurements of MMFR revealed the lowest values in the cystic fibrosis patients. The findings of Zelhowitz and Giammona[6] were similar.

Comparison of peak flow rate with maximal midexpiratory flow rate revealed a correlation co-efficient of 0.936 in normal children and 0.872 in cystic fibrosis patients.

A high degree of correlation was found by Rosenblatt[23] and Fairbairn[39] in normal children and patients, the correlation being 0.85 and 0.836, respectively.

Maximal volume obtained by voluntary effort is affected not only by the patency of the airways, but also by the factors such as muscular force, the compliance of the lungs and thoracic tissues. For these reasons, reduction in maximal voluntary ventilation must be large to be significant in the obstructive airway disease.[41] Values of this measurement were found significantly low in cystic fibrosis patients in this study. The correlation between peak flow rate and maximal voluntary ventilation was high and the correlation co-efficient was calculated to be 0.826 in normal children and 0.877 in cystic fibrosis patients. Other studies have also demonstrated high degrees of correlation between PFR and MVV

Kamat[21], Prime[22], Rosenblatt[23], Kazemi[25] and Olsen[42] have calcu-. lated the correlation co-efficients of 0.88, 0.86, 0.66, 0.80 and 0.80 in order.

Different opinions have been expressed by several investigators about the role of the peak flow rate. Leiner[19] and Fairbairn[39] have pointed out that determination of the peak flow rate would not permit the differentiation between the restrictive and obstructive pulmonary disease, but most of the studies agreed about the usefulness of peak flow rate measurement in differentiation of the normals from patients and in determination of the degree of the obstruction. It was also concluded that the test was a reliable, simple and reproducible one by many investigators.[13-22-25]

Some investigators have found significant increases after administration of bronchodilating drugs to cystic fibrosis patients. Royce[27] found a 20 % increase in maximal voluntary ventilation, Gandevia[26] observed a 10 % increase in timed vital capacity, and Doershuk et al[43] pointed out that some of the cystic fibrosis patients may respond to bronchodilating drugs if they have bronchospasm.

In this study, administration of bronchodilating drugs to the patients resulted in a statistically nonsignificant (5-9 %) increase in measurements ($P > 0.4$).

Conclusion

Peak flow rate (PFR) measured with a Wright peak flowmeter, forced expiratory volume in one second (FEV_1), maximal midexpiratory flow rate (MMFR), and maximal voluntary ventilation (MVV) measured with a spirometer were found to be decreased in cystic fibrosis patients.

Comparison of measurements obtained from patients with the measurements of normal children, revealed a statistically significant difference. Forced expiratory volume in one second, maximal voluntary ventilation and peak flow rate were proportionally low in cystic fibrosis disease and it was concluded that peak flow rate measurement could be used instead of these two tests.

Maximal midexpiratory flow rate in cystic fibrosis patients was lower than peak flow rate in the same patient group. Since the maximal midexpiratory flow rate seems to be a more sensitive index for evaluation of the obstruction, determination of it was thought to have superiority over peak flow rate. On the other hand, significant differences between

the values of peak flow rate obtained in cystic fibrosis patients compared with those of normal children, supported its values in differentiation of the patients from the normal children.

High correlation co-efficients were obtained by comparing the peak flow rate with FEV_1 and MMVR which are widely used to determine the obstruction. Therefore the measurement of peak expiratory flow rates proved to be useful as an indirect index of airway resistance in this study.

The peak flow rate, given before and after a trial of bronchodilating drugs in children with cystic fibrosis, resulted in an increase which was statistically nonsignificant. It was thought that this finding might be due to an absence of bronchospasm in this group of patients and the severity of the lung disease.

Summary

This study was done to determine the role of the Wright peak flowmeter for evaluation of pulmonary functions in children with cystic fibrosis. Peak expiratory flow rate was measured with the use of a Wright peak flowmeter and one second forced expiratory volume, maximal mid-expiratory flow rate and maximal voluntary ventilation were measured with a spirometer in a total of 55 children, 25 of whom had cystic fibrosis disease, with the remainder being normal.

Measurements were repeated after administration of bronchodilating drugs to the cystic fibrosis patients.

All the values of the four measurements were decreased significantly in the cystic fibrosis patients. Positive and significant correlation co-efficients were obtained by comparing the peak flow rate with other spirometric measurements.

It was concluded that peak expiratory flow rate is a feasible and useful measurement of pulmonary functions in cystic fibrosis patients. No changes were observed after administration of bronchodilating drugs to these patients.

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