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PULMONARY FUNCTION IN PATIENTS WITH NEUROMUSCULAR DISORDERS

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Abstract

Fourteen patients with neuromuscular disorders were studied for changes in lung function, especially in the maximal expiratory flow volume curve (MEFV curve).

Comparison was made with findings in patients with PSS.

Changes of lung functions were mainly of restrictive type characterized by decrease in vital capacity, total lung capacity and by increase in residual volume with normal value of $FEV_{1.0}$ and respiratory resistance.

Arterial blood gases showed normal oxygen tension and normal or lowered carbon dioxide tension in most of patients.

MEFV curve in the neuro-muscular disorders revealed a slow increase of initial ascending limb, lower peak flow and concavity toward the volume axis of terminal portion (normal $\dot{V}_{25}$), which contrasted with MEFV curves of PSS patients, the curves of which showed convexity of terminal portion (decreased $\dot{V}_{25}$). The slow increase of ascending limb and lower peak flow in the former may be an expression of the decreased muscle strength, which was demonstrated by the simultaneous slow increase and small change of the transpulmonary pressure. Normal $\dot{V}_{25}$ of MEFV curves may be the evidence of intact lung in the neuromuscular diseases.

INTRODUCTION

There have been many reports on respiratory failure or pulmonary infection which contributes to death in patients with neuromuscular

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disorders.[1,2,3] If lung functions of these patients are investigated in more details, therapy on respiratory failure would be easier.

This study was, therefore, undertaken to see whether lung function tests, especially maximal expiratory flow volume curve (MEFV curve, the new tool of detecting early airway changes)[4,5] could find any characteristic of these patients, comparing these data with those obtained from patients with progressive systemic sclerosis (PSS) which was considered to involve interstitium of the lung and yet present restrictive ventilatory disturbance similar to that of patients with neuromuscular diseases.

MATERIALS

A total of 14 cases with neuromuscular disorders were examined. The diagnosis was established in all cases several years prior to this study on grounds of clinical evidence. The subjects received regular care as outpatients in our hospital.

Eight patients of dystrophia musculosum progressive (DMP) (three were Duchenne type, five were limb-girdle), one of myotonic dystrophy, two of ALS and three of other diagnosis were included. Their clinical data are shown in Table 1. Ages ranged from 8 to 53 with average age of 35 years. For a comparison of lung function, 5 patients with progressive systemic sclerosis were selected.

TABLE 1.
Clinical Data of Patients with Neuromuscular Disorders

Diagnosis	Sex	Number	Age	Duration of Disease
DMP (Duchenne)	M	3	8~13	3~6
DMP (L-G)	M	4	16~30	3~7
	F	1	50	30
Myotonic dystrophy	M	1	25	10
ALS	M	1	50	6
	F	1	46	6
Myasthenia gravis	F	1	53	7
M. S.	F	1	46	2
SPMA	M	1	51	2

METHODS

Lung volumes and functional residual capacities were measured by FRC computer. Values were expressed at body temperature, pressure saturated (BTPS). Forced expiratory volume in one second ($FEV_{1.0}$) and maximal mid-expiratory flow rates were calculated from the forced vital capacity on the spirogram.

Diffusing capacity; Pulmonary diffusing capacity was measured by single breath method with Resparameter (Morgan Ltd.).

Blood gases; Arterial blood gases were taken from brachial artery by single puncture method[6] and samples were collected in a glass syringes in which the dead space was filled with heparin and samples were immediately examined. Partial pressure of carbon dioxide, oxygen and pH were determined on I-L meter.

Flow volume curve; it was measured by Sanwa flow volume curve recorders.

Respiratory resistance; it was measured by Nihonkoden respiratory resistance meter MRP 6.

In some of the patients, simultaneous measurements of flow, volume and transpulmonary pressure were taken with a pneumotachometer to see the time relationship of each other.

RESULTS

All values of lung functions obtained from patients with the diseases are listed in Table 2. In some of the cases, residual volume and diffusing capacity could not be measured because of spinal deformity or other neurological defects. Allowing for the physiological differences, vital capacity and pulmonary diffusing capacity were expressed as per cent of predicted value.

Per cent vital capacity was reduced below the range of normal in 9 of 14 cases with a large variation ranging from 33 to 84 per cent according to types and duration of illness. Total lung capacity tended to decrease and RV/TLC ratio was mostly increased except for one case of the myotonic dystrophy with value of 23 %. MMFR showed decreases in most of cases and $FEV_{1.0}$ and respiratory resistance were all within normal limits.

Diffusing capacity was normal except one case.

Arterial blood gases were taken in 13 cases. In 12 of 13 cases, arterial oxygen tensions were higher than 70 mm Hg. Carbon dioxide tension remained normal or lower than normal and pH was normal.

TABLE 2. Lung Functions in Neuromuscular Diseases

No.	Diagnosis	Sex	Age	Duration (years)	VC (%)	TLC (ml)	RV/TLC (%)	$FEV_{1.0}/VC$ (%)	MMFR L/sec	R_R $CmH_2O/L/S$	D_{LCO} (%)	MEFV curves PF	MEFV curves $\dot{V}_{50}$	MEFV curves $\dot{V}_{25}$	Po_2 mmHg	Pco_2 mmHg	pH
1	D.M.P. (DUCHEN.)	M	8	3	98	2970	39	93	2.4	4.3	72	2.7	2.0	1.2	122	18.1	7.646
2	D.M.P. (DUCHEN.)	M	9	3	48	/	/	90	1.2	5.0	/	1.8	1.8	1.5	94.5	31.3	7.388
3	D.M.P. (DUCHEN.)	M	13	6	105	4310	35	96	2.7	2.4	/	4.6	2.6	1.6	107	36.7	7.389
4	D.M.P. (L-G)	M	16	4	65	5120	50	96	4.7	3.2	101	5.4	4.5	3.0	101	35.0	7.395
5	D.M.P. (L-G)	M	27	3	105	6830	36	96	5.8	1.7	90	7.8	4.5	2.2	108	38.0	7.393
6	D.M.P. (L-G)	M	30	5	35	7160	50	88	1.7	1.5	84	2.5	1.7	0.7	85.4	40.6	7.372
7	D.M.P. (L-G)	M	20	7	62	5430	49	98	3.3	3.3	22	2.0	2.0	1.6	79.4	40.5	7.394
8	D.M.P. (L-G)	F	50	30	32	4910	83	100	1.0	1.0	/	1.0	0.9	0.8	86.8	33.8	7.399
9	SPMA	M	51	2	81	/	/	71	1.7	3.2	/	2.9	2.2	0.8	/	/	/
10	Myot. Dystro	F	25	25	89	3610	23	87	2.6	2.4	83	5.3	4.6	2.7	70.2	39.6	7.388
11	ALS	M	50	6	76	4140	51	80	1.2	2.0	94	1.6	0.9	0.4	60.3	42.2	7.406
12	ALS	F	46	6	59	3040	51	92	1.6	3.8	100	2.8	2.2	1.2	72.1	39.1	7.423
13	Mya. Gravis	F	53	7	59	/	/	79	1.5	2.6	110	3.0	2.5	1.2	79.7	37.6	7.384
14	M.S.	F	46	2	76	4110	53	93	2.3	1.9	133	3.0	2.4	1.2	92.5	33.2	7.423

Values of lung functions of PSS patients are shown on Table 3. VC was decreased in 3 of 5 cases and TLC showed similar decrease as those of patients with neuromuscular disorders. Respiratory resistances were not significantly increased. Diffusing capacity was decreased in 3 of 5 cases. Arterial oxygen was normal and carbon dioxide tension was normal except one.

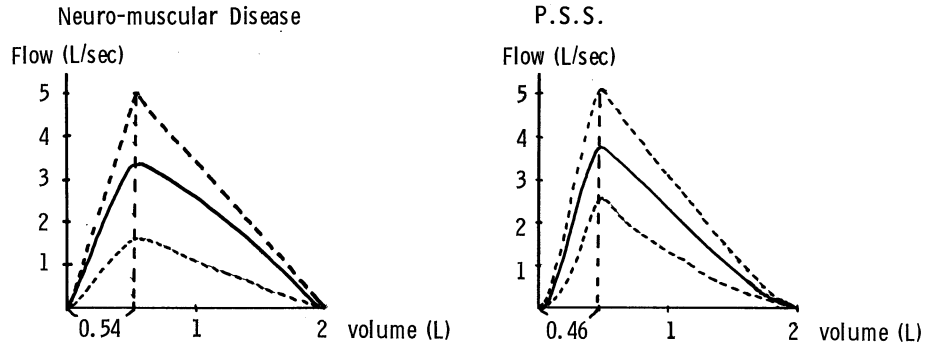
TABLE 3.

Lung Functions in PSS

No.	Diagnosis	Sex	Age	Duration (years)	VC (%)	TLC (ml)	RV/TCL (%)	$FEV_{1.0}/VC$ (%)	MMFR L/sec
1	PSS	F	47	5	81	4180	50	82	1.7
2	PSS	F	52	8	90	3650	39	81	1.8
3	PSS	F	40	3	69	2940	34	86	2
4	PSS	F	30	3	52	2410	41	78	1.0
5	PSS	F	40	5	71	3540	45	79	1.6

No.	Diagnosis	Sex	R_R $CmH_2O/L/S$	D_{LCO} (%)	MEFV curves PF	$\dot{V}_{50}$	$\dot{V}_{25}$	Po_2 mmHg	Pco_2 mmHg	pH
1	PSS	F	2.7	86.7	5.6	2.3	0.7	91.4	36.0	7.400
2	PSS	F	1.1	52	2.5	1.9	1.1	84.9	28.5	7.436
3	PSS	F	2.4	49	4.1	3.1	0.6	73.5	36.6	7.427
4	PSS	F	3.2	78	2.0	1.5	0.3	74.3	44.5	7.386
5	PSS	F	2.0	91	3.7	2.7	1.1	83.0	40.7	7.410

The flow volume curves of patients with neuromuscular diseases were variable, but slow increase of initial ascending limb, decreased peak flow and concavity toward the volume aixs of the terminal portion of the expiratory limb were the characteristic pattern in these patients. Figure 1 is the schematic representation of mean MEFV curves of DMP and PSS patients. Middle thick line shows the mean of the observed values and uppermost and bottom dotted lines show the standard deviation. Slow increase of ascending limb, lower peak flow and straight curve of terminal portion in the neuromuscular diseases clearly contrasted with that of PSS. Figure 2 shows the simultaneous records of the flow, volume and transpulmonary pressure plotted against time in DMP



LVC = 1.99 ± 0.83
PF = 3.38 ± 1.79
V̇50 = 2.59 ± 1.23
V̇25 = 1.41 ± 0.72

LVC = 1.98 ± 0.29
PF = 3.81 ± 1.24
V̇50 = 2.38 ± 0.6
V̇25 = 0.75 ± 0.30

Fig. 1

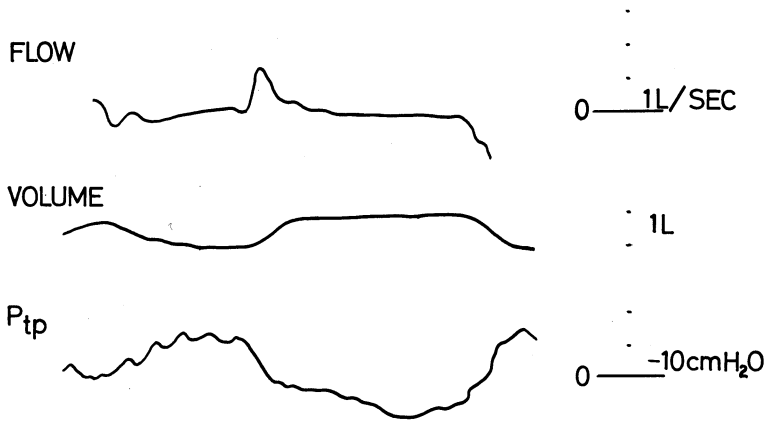


Fig. 2. M.K. DMP 50 year female

patient illustrated on mingograph during forced expiration through pneumotachometer. The top panel depicts the slow increase of initial expiratory flow and decreased peak flow. Vital capacity (middle pannel) remained very low. Transpulmonary pressure (bottom panel) was kept small range from −13 to +10 cm H_2O comparing with that of normal

control shown in Figure 3. Figure 4 shows the simultaneous records of the flow, volume and transpulmonary pressure plotted against time in PSS patient. Low peak flow and decrease in vital capacity was similar to those of DMP patients but transpulmonary pressure revealed a wide range from -35 to $+25$ cm H_2O.

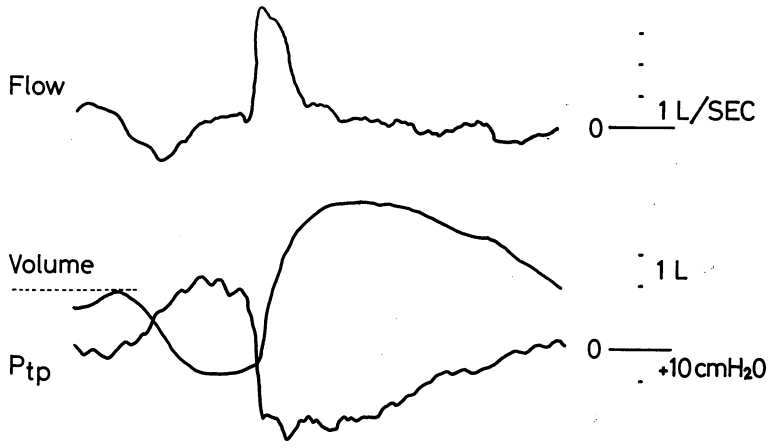


Fig. 3. Normal Subject

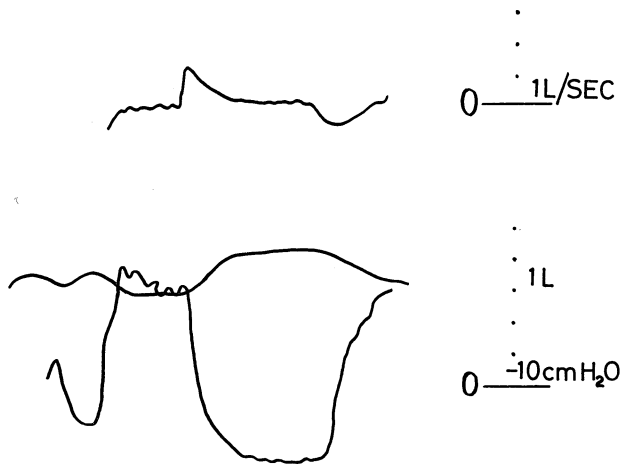


Fig. 4. M. T. PSS 30 year female

DISCUSSION

We found great variations in the values of the parameters of lung function in patients with neuromuscular disorders. These results might

have been brought up by different category and stage of the diseases which we had selected. Campbell[7] classified the functional grades of respiratory muscle into three.

1. Weakness insufficient to reduce the functional reserve of breathing; in the early stage, the functional reserve of the respiratory muscles is very great and normally not measurable by such tests as vital capacity.

2. Weakness sufficient to reduce the functional reserve but adequate for resting ventilation; the most widely used tests at this stage is the vital capacity. Additional tests such as inspiratory and expiratory reserve volumes, MVV and reserve volume may show abnormal but resting ventilation is sustained so blood gases usually show normal values.

3. Values sufficient to cause inadequate pulmonary ventilation; at this stage pulse or respiration or blood pressure tends to rise and inadequate ventilation results in a low oxygen tension and carbon dioxide retention.

Considering this classification, a distinct pattern of clinical findings and lung function data emerged for the group of neuromuscular disease despite the great variation observed among individuals. When the patients show the normal values in lung function tests, they might be at an early stage of the disease.

As a group, lung function tests revealed restrictive type evidenced in the decrease in vital capacity, total lung capacity and in the increase of % RV/TLC ratio with normal values of $FEV_{1.0}$ and respiratory resistance. Our results are in close agreement with values found by others.[8,9,10,11] It is very difficult, however, to decide the possible cause for the restrictive disturbances in the diseases. Among these are scoliosis, limitation of intercostal movement, deviation of diaphragm, atelectasis of lung tissues and muscular weakness. Ringqvist[8] regarded the most likely cause of the disturbances as the decrease of thoracic compliance by comparing lung function abnormalities of the patients with those obtained from normal subjects whose vital capacities were reduced by tight chest strapping. Most workers[3,12,13] regard the most contributing factor in the disturbances of lung function of the patients as muscular weakness. Considering normal chest x-ray and pulmonary diffusing capacity in our patients, it appears reasonable to assume that muscular weakness is primarily responsible for the impairment of pulmonary function.

Arterial oxygen tensions were normal in most of our cases. Wahi[9] and Scott[11] reported the normal values of arterial oxygen tension in most of their patients with DMP but Hapke[10] reported lowered oxygen saturation in 11 of 19 children and he suggested uneven ventilation/perfusion relationship as the most likely cause for the hypoxemia by observing the uneven distribution of inspired gas during the closed circuit helium dilution test. McCormack[1] also reported a case of DMP with papilledema, lowered oxygen saturation and carbon dioxide retention. These results seem to be conflicting, but on the basis of this study, we think patients without severe respiratory failure or tract infection can keep the level of arterial oxygen within normal unless the illness reaches the terminal stage. Carbon dioxide of our patients remained normal or lowered. This might be explained by compensatory mechanism which worked to keep oxygen tension to normal level by hyper-ventilation[10] or by the decreased muscle activity which resulted in energy saving of the body and reflected in the arterial carbon dioxide with lowered level[9,13]

The maximal flow volume curve was proposed by Hyatt.[4] Since then, the MEFV curve has been widely used and recently it has been observed that MEFV curve could detect small airway disease[5,14] and we also confirmed the usefulness of the test.[15]

From the present observation it was shown that initial flow of the MEFV curve in the diseases had slowly increased with lower peak flow and flows of the terminal portion ($\dot{V}_{50}$, $\dot{V}_{25}$) were relatively well preserved, which contrasted with those in PSS patients, the disease process of which was said to involve the interstitium of the lung. This finding was confirmed by the simultaneous recording of the flow, volume and transpulmonary pressure in the figure 2. Less negative pressure in the early phase of the forced expiration might have failed to produce the sharp rise in the flow and the preserved flow of terminal portion would imply the intact small airways in the neuromuscular disease.

Therefore, MEFV curve in combination with conventional lung function tests would be very helpful in the differentiation between diseases with neuromuscular disorder which might to involve only respiratory muscle and those with PSS and other collagen disorders which involve mainly interstitium of the lung.

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