

Analysis of Maximal Expiratory Flow-volume Patterns in Sea-squirt Asthma Patients

Key Word: Sea-squirt asthma—Maximal expiratory flow-volume pattern—Fractional flow rates

Since Jyo et al.¹⁻²⁾ reported sea-squirt asthma was in oystershucking workers in Hiroshima, this disease has been considered a type of occupational asthma³⁾. This disease is closely related to an allergy in which oyster fluid is the allergen.^{2,4)} Prior to improvement in the environment of oystershucking workplaces, most workers who inhaled sea-squirt fluids developed asthmatic symptoms, rhinitis, conjunctivitis, bronchitis and bronchial asthma at night after work. Thus, machines to remove sea-squirt from the shells were set up in a garden outside the workplace. Kimura et al.³⁾ and Jyo et al.¹⁻²⁾ reported that improvement in the workplace for prevention and hyposensitization therapy for the specific antigen was useful in the recovery of patients from exacerbations of asthma.

For evaluating occupational asthma, it is useful to test maximal expiratory flow-volume (MEFV) to determine ventilatory ability. But this method has not been used to evaluate sea-squirt asthma patients. MEFV measurement should be useful to follow patients with sea-squirt occupational asthma and occupational nasal allergy patients.

To determine the degree of lower airway obstruction in asymptomatic sea-squirt asthma patients during the oystershucking work period, maximal expiratory flow-volume was measured.

Seven non-smoking sea-squirt asthma patients, one male and six females, were chosen for this study. All had been employed in the oyster-shucking occupation for more than fifteen years with a mean duration of 24 years. The mean period of time employed prior to the onset of asthmatic symptoms was 11.7 years. The sea-squirt asthma patients have received hyposensitization therapy with sea-squirt extracts for the prior five years, and their asthmatic symptoms were greatly improved from the initial diagnosis. Their asthmatic attacks did not occur outside the oystershucking-work season. All of the patients were in remission for one year including the last work-season. All were evaluated by pulmonary function tests and physical examinations during the oystershucking work season. On the test day, all were asymptomatic and they were normal physically. All subjects reacted positively to intracutaneous skin testing with sea-squirt extracts (x1000). Nine healthy housewives were chosen as controls. They had no respiratory allergy symptoms, normal physical conditions, no history of respiratory disease, and no smoking habits. They lived in southern Okayama Prefecture.

Their maximal expiratory volume-time and flow-volume were tested using a volume-time and flow-volume curve recorder (AS-4500, Minato Co. Ltd.). Each MEFV pattern was classified according to the MEFV pattern classification in allergic airway disorders described by the authors.⁹⁾ Three types of MEFV patterns (types A, E1 and E2) were used to classify deviation from the standard. Type A includes persons without respiratory defects; the MEFV tracing has a triangular shape. Type E1 subjects have slight lower airway obstruction and the MEFV tracings do not have an obvious sudden flow decrease immediately following peak expiratory flow rate (PEFR), but show a slightly concave shape in the down-slope of the curves. Type E2 subjects have moderate lower airway obstruction as shown by an obvious sudden flow decrease immediately after PEFR. Type E1 and E2 in this study correspond to type E1 and E2 in the previous study.⁹⁾

Pulmonary function indices were calculated from the curves. Four MEFV flow rate indices (PEFR, Flow75, Flow50, and Flow25) were corrected to a body height of 1m and designated PEFR', Flow75', Flow50' and Flow25'. Three maximal expiratory flow rates, Flow75, Flow50 and Flow25, representing flow rate at 75%, 50% and 25% of forced vital capacity, respectively, were fractionated for all patients using the following equation and designated Fr-x.

$$\text{Fr-x}(\%) = [\text{Flow-x}/\text{PEFR}] \times 100$$
, where X is the percentage of lung volume to forced vital capacity. The mean values, unbiased standard deviation, Student's t-test and Welch's test were calculated for the group of subject types E1, and E2, and the type A group of healthy subjects (A' group).

A representative maximal expiratory flow-volume (MEFV) pattern for sea-squirt asthma patients is shown in Fig. 1. Two MEFV charts (B' and C') showed sudden flow decreases immediately following PEFR and were classified as type E2, i.e., with typical asthmatic patterns. Two MEFV charts (D' and E') showed no obvious sudden flow decreases, but were slightly concave and were classified as type E1. Significantly, the MEFV patterns showed slight or moderate lower airway obstruction even in remission. Thus, we classified sea-squirt asthma patients into two groups (E1 and E2). The pulmonary function results for these two groups and healthy controls are listed in Table 1-A. The results of corrected flow rates (flow rates corrected to a body height of 1 m) and fractions (%) of flow rates are shown in Table 1-B. The mean values for corrected flow rates (Flow75' and Flow50') in the sea-squirt asthma patients were significantly different between the E1 and E2 groups. The mean Fr75 and Fr50 were also different in the two groups. The mean values for all corrected flow rates (PEFR', Flow75', Flow50'), and for all fractions (Fr75, Fr50 and Fr25) of flow rates were significantly different between type A, the healthy controls, and the E2 group of sea-squirt asthma patients. The mean values for fractional flow rates, Fr50 and Fr25, were also significantly different between type A and the E1 group. This indicates that Fr75 and Fr50 are suitable parameters to detect sudden flow

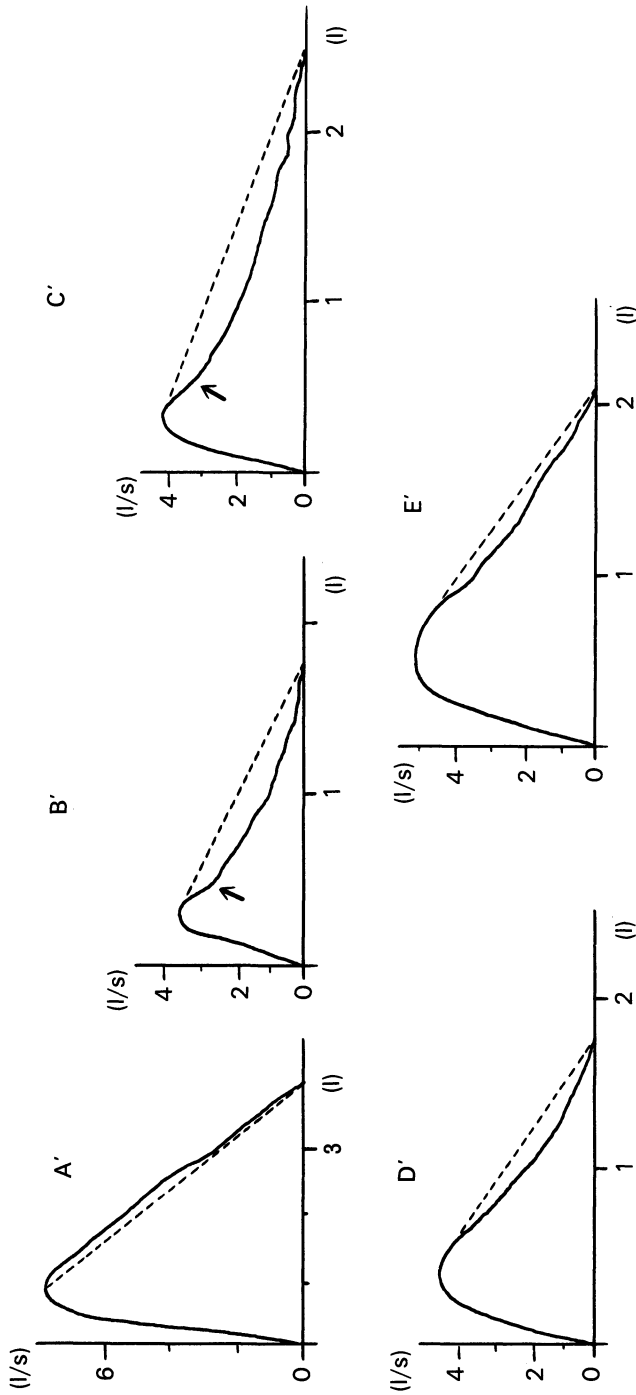


Fig. 1 Representative maximal expiratory flow-volume patterns in healthy controls and sea-squirt asthma patients.

A': Type A, healthy controls. B' and C': Type E2, sea-squirt asthma patients. D' and E': Type E1, sea-squirt asthma patients.

Type A, E1 and E2 are described in the previous paper.⁹

Arrow indicate the flow sudden decrease immediately following peak expiratory flow rate and MEFV patterns A', B', C', D' and E' were classified by the grade of the flow decrease. The dotted line indicates the normal flow changes according to the volume.

Table 1-A. Physical factors, conventional spirometry and maximal expiratory flow-volume data in sea-squirt asthma patients.

Case Sex	Age	Body	Conventional spirometry				MEFV			
	(yrs)	Ht (m)	FVC (l)	FEV1 (l)	%FVC (%)	FEV1% (%)	PEFR (l/s)	F75 (l/s)	F50 (l/s)	F25 (l/s)
Type E2 group (N=4)										
Mean	59	1.52	2.44	1.76	101.3	72.9	4.66	3.34	1.68	0.54
USD	10.8	0.04	0.40	0.13	10.8	6.6	0.09	0.51	0.28	0.09
Type E1 group (N=3)										
Mean	42	1.54	2.82	2.32	95.3	83.8	6.25	6.18	3.11	1.11
USD	10.5	0.09	0.56	0.58	7.3	2.3	1.55	1.61	0.90	0.45
Healthy controls (A type) (N=9)										
Mean	44	1.54	2.89	2.51	106.7	86.3	6.09	5.75	3.99	1.52
USD	3.2	0.05	0.26	0.19	7.0	3.1	0.61	0.60	0.75	0.30

Mean: Mean value, USD: Unbiased standard deviation.

Table 1-B. MEFV and fraction of flow rates in sea-squirt asthma patients.

Group Sex Case	MEFV				Fraction of flow rates		
	PEFR* (l/s/m)	F75* (l/s/m)	F50* (l/s/m)	F25* (l/s/m)	Fr75 (%)	Fr50 (%)	Fr25 (%)
Type E2 group							
Mean	3.078	2.210	1.113	0.356	71.53	36.03	11.45
USD	0.135	0.382	0.208	0.066	10.64	5.61	1.64
Type E1 group							
Mean	4.043	3.993	2.007	0.717	98.63	49.37	17.30
USD	0.738	0.781	0.453	0.244	1.19	2.32	2.75
Healthy controls							
Mean	3.956	3.735	2.595	0.987	94.49	65.81	25.12
USD	0.376	0.359	0.463	0.203	3.76	11.35	5.87
Healthy subjects vs MEFV type E1 patients							
t-test							
(E1-E2)	(—)	(*)	(*)	(—)	(*)	(*)	(*)
(A-E2)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
(A-E1)	(—)	(—)	(—)	(—)	(—)	(*)	(*)

Mean: Mean value, USD: Unbiased standard deviation.

Healthy controls: Type A.

E1-E2, A-E2 and A-E1: Student's t-test between type E1 and type E2, between type A (healthy controls) and type E2, and between type A and type E1.

decreases. There was a marked lower airway obstruction in the E2 type sea-squirt asthma patients and slight lower airway obstruction was suspected in the E1 type sea-squirt asthma patients. From the results in these sea-squirt asthma patients in remission, it appears that MEFV measurement is useful for

detection, evaluation of therapy and supervision of occupational asthma patients.

MEFV tracings of allergic airway patients show characteristic patterns⁵⁻⁷⁾ corresponding to the degree of asthmatic or nasal symptoms. We have reported⁹⁾ that in allergic airway patients, the MEFV patterns can be classified into seven types (A, B, C, D, E₁, E₂ and E₃). The three E type MEFV charts (E₁, E₂ and E₃) measured three grades of lower airway obstruction. This classification can be applied to the pulmonary function in sea-squirt asthma patients. These MEFV charts represent characteristic patterns corresponding to the broncho-pulmonary ventilatory dynamics due to inhalation of specific antigens or due to non-specific airway obstruction. The average age of the sea-squirt asthma patients classified as type E₁ was 45 years old and for type E₂, 61 years old. Obstruction of the lower airways gradually increased with age. Thus, the decrease in the flow-rate of low lung volumes becomes more prominent with age. However, the sudden flow decrease occurring just after peak expiratory flow-rate occurred in E₂ type sea-squirt asthma patients but not in the older control subjects without asthmatic symptoms. The lowering of Fr50 and Fr25 in the E₁ type sea-squirt asthma patients is thought to reflect the older patients in that group. The precise effect of age will be studied later. Differences between sexes usually occur in pulmonary function. But MEFV tracings have common characteristic patterns between males and females, as described in our previous paper.^{5,7)} However, flow rates and volumes expired are affected by gender. Flow rates corrected to a body height of 1 m (corrected flow rates) and fractions (%) of flow rates apparently decrease the difference between males and females. Thus, corrected flow rates and fractional flow rates can be used in the analysis of MEFV patterns, including both sexes.

In conclusion, MEFV tracings are useful in assessing the degree of airway obstruction in occupational respiratory allergic diseases including sea-squirt asthma.

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