Original Article
Values of portable peak velocity meter in diagnosing and treating chronic airflow obstruction disease

Meirong Liu*, Ming Li*, Jia Zhou, Xiaofeng Tan

*Department of General Internal Medicine, Tianjin Hospital, Tianjin, China. *Equal contributors.*

Abstract: Background: The chronic airflow obstruction disease (CAOD) is a common disease with long duration and difficulty for treatment. The percentage of early detection and treatment of CAOD is low, resulting in poor therapeutic effects and poor prognosis. This study aimed to investigate the values of portable peak velocity meter in diagnosing and treating CAOD. Methods: 329 patients diagnosed with suspicious CAOD were enrolled in this study. The portable peak velocity meter was used to detect the peak expiratory flow (PEF) during the first diagnosis. The lung function test was performed in 159 patients, and the 3-day PEF monitoring was conducted in 277 patients. Results: The final diagnosis rate and hospitalization rate of CAOD of the PEF% (PEF-prediction ratio) < 80% group were higher than the PEF% ≥ 80% group, the 3-day treatment efficiency was lower than the PEF% ≥ 80% group; the correct completion rate of PEF variation rate monitoring was lower than the failure rate; as for the CAOD patients with airway hyperresponsiveness, the negative transferring rate of PEF variation of the effective 3-day treatment group (PEF variation rate was dropped to 20% or less) was higher than the ineffective 3-day treatment group. Conclusions: Although fewer patients properly use the portable peak velocity meter for the self-monitoring, the meter can still quickly adjunctively diagnose CAOD, as well as predict the short-term prognosis and treatment effects.

Keywords: Portable peak velocity meter, peak expiratory flow, chronic airflow-obstructive disease, prognosis

Introduction

The chronic airflow obstruction disease (CAOD) is commonly seen in asthma, chronic obstructive pulmonary disease (COPD), overlapping syndrome (overlapping of sleep apnea syndrome and COPD), etc. These diseases have long duration, and are difficult to be treated. There are approximately 300 million of people worldwide who are affected by asthma, accounting for 1% of total global disease burden [1, 2]. Some experts propose that, till 2020, the social and economic burdens of COPD worldwide will rise to the 5th position, and COPD will become the 3rd leading cause of death [3]. According to Chinese statistics [4], the annual medical cost of each COPD patient caused by the acute exacerbation is as high as 11,598 yuan. Study [5] on overlapping syndrome points out that, the repeated exacerbation can cause the acute hypoxemia and/or respiratory failure, thus accelerating the disease process and leading to the chronic respiratory failure. But the clinical work finds that,

the percentage of early detection and treatment of CAOD is low, resulting in the poor therapeutic effects towards the late stage of such diseases, as well as the poor prognosis.

The portable peak velocity meter has been used in the fields of education and self-monitoring of bronchial asthma patients. It can be readily used to detect the peak expiratory flow value of the patient. The Asthma Prevention Guide [6] proposes that, if the PEF measured value is less than 80% of predicted personal value, there may be existence of airway obstruction. If the PEF variation rate is ≥ 20%, it will indicate the diagnosis of asthma. The PEF variation rate is a good indicator that reflects the airway responsiveness, and is closely related to the results of bronchial stimulation test [7]. The PEF variation rate ≥ 20% suggests that, the patient has the greater likelihood of airway hyperresponsiveness. For example, some patients with cough variant asthma exhibit normal results in the early pulmonary function tests, but the dynamic monitoring of PEF varia-

tion rate can reveal the subtle changes of PEF in the patients, which contribute to the definite diagnosis [8]. As for the COPD patients, the guideline proposes that, the correlation between PEF and FEV1 (forced expiratory volume in the 1st second) was not strong enough. PEF may underestimate the degree of airflow obstruction, so the researches related to the PEF detection of COPD patients are fewer and fewer [9]. However, if the airway obstruction or airway hyper responsiveness can be found as early as possible towards the patients with long-term smoking history, unexplained chronic cough, insensitive respiratory symptoms or severe asthma, it can assist the diagnosis and prevent the disease from exacerbation. This study strictly guided the patients to accurately measure the PEF values using portable peak velocity meter, and collected various information for a long time, aiming to observe the application value of peak velocity meter in the diagnosis and treatment of CAOD.

Subjects and methods

Subjects

329 patients who were diagnosed with suspicious CAOD in the community clinic general internal medicine clinic, inpatient department and medical emergency department of Tianjin Hospital from March 2011 to March 2014 were enrolled in this study. There were 197 males and 132 females, with mean age as 41.2±9 years old. This study was conducted in accordance with the declaration of Helsinki and the approval from Ethics Committee of Tianjin Hospital. Written informed consent was obtained from all participants.

Data collection and recording

A unified case observation table was developed. When the patients visited the clinic, their clinical data were collected by the specialist, including the patient's name, sex, age, contact information, height, weight, medical history of current disease, previous history of disease, physical examination and PEF measurements. PEF%/predicted individual value and PEF variation rate value were calculated. If the error of two PEF measurements was less than 10 L/min, it could be considered as the valid measurements. The follow up was performed towards the patients about the final diagnosis,

hospitalization or not, as well as the remission of clinical symptoms within 3 days.

Inclusion criteria and exclusion criteria

Inclusion criteria: (i) existed at least one of such symptoms as coughing, chest tightness, breath shortness and gasping; (ii) existed the previous long-term history of one of such diseases as smoking, chronic bronchitis, emphysema, unexplained chronic cough, asthma, COPD, sleep apnea syndrome. Exclusion criteria: (i) could not correctly cooperate with the examiner; (ii) with a history of pulmonary resection; (iii) diagnosed as muscle weakness; (iv) severe asthma; (v) with pneumonia; (vi) pulmonary thromboembolism symptoms; (vii) acute left ventricular failure; (viii) acute myocardial infarction, angina pectoris.

Detection using portable peak velocity meter

The PEF-3 peak velocity meter (Shanghai Wanbo Science and Technology Co., Ltd., Shanghai, China) was used for detection, according to the manual instructions. The PEF in each patient was detected for at least 3 times, and the maximum value was recorded. PEF monitoring was performed 4 times daily (6:00, 12:00, 18:00, 24:00), with 3 repetitions for each time. The highest value was recorded as the result.

Calculation formula

(i) Adult PEF predicted value: male: PEF (L/min) = 75.6 + 20.4 × A - 0.41 × A^2 + 0.002 × A^3 + 1.19 × H; female: PEF (L/min) = 282.0 + 1.79 × A - 0.046 × A^2 + 0.68 × H. (ii) Child PEF predicted value: male: PEF (L/min) = 5.29 × H - 427.1; female: PEF (L/min) = 4.94 × H - 399.8. A was the age (years), and H was the height (cm). (iii) PEF variation rate = 2 ($PEF_{highest}$ - PEF_{lowest})/($PEF_{highest}$ + PEF_{lowest}) × 100%.

Statistical analysis

Data were expressed as mean ± SD. Statistical analysis was performed using SPSS 17.0 statistical software. The comparison of rate was performed using 2 × 2 list χ^2 test and likelihood ratio test. The categorical variables were compared using the 2 × 2 pairing-data correlation analysis. $P < 0.05$ was considered as statistically significant.

Table 1. Comparison of final diagnosis rate of CAOD between two groups

Group	Diagnosed as CAOD (n)	Others (n)	Total (n)	Diagnostic rate (%)
PEF% < 80%	86	40	126	68.25
PEF% ≥ 80%	27	176	203	13.30
Total	113	216	329	34.35
χ^2		104.11		
P		0.012		

Table 2. Comparison of hospitalization rate of CAOD between two groups

Group	Hospitalized (n)	Non-hospitalized (n)	Total (n)	Hospitalization rate (%)
PEF% < 80%	20	66	86	23.26
PEF% ≥ 80%	1	26	273	3.70
Total	21	92	113	18.58
χ^2		3.98		
P		0.009		

Results

Comparison of final diagnosis rate, hospitalization rate and 3-day treatment efficiency rate between two groups

Among the 329 patients, the PEF% < 80% group had 126 patients and the PEF% ≥ 80% group had 203 patients. Among the PEF% < 80% group, 86 patients were finally diagnosed as one of asthma, COPD and overlapping syndrome, and the diagnosis rate was 68.25%. Among the PEF% ≥ 80% group, 27 patients were finally diagnosed as one of asthma, COPD and overlapping syndrome and the diagnostic rate was 13.30%. There was significant difference of diagnostic rate between two groups (χ^2 = 104.11, P = 0.012) (**Table 1**). These results suggested that, when the patients were preliminary measured with PEF% < 80%, they should be highly suspected as CAOD, and be performed with the further active examination and treatment, while the patients initially measured with PEF% ≥ 80% should not be excluded from CAOD.

Among 86 patient diagnosed as CAOD in the PEF% < 80% group, 20 patients were hospitalized, and the hospitalization rate was 23.26%. Among the 27 patients diagnosed as CAOD in the PEF% > 80% group, 1 patient was hospitalized, and the hospitalization rate was 3.70%.

There was significant difference of hospitalization rate between two groups (χ^2 = 3.98, P = 0.009) (**Table 2**). Among 86 patients diagnosed as CAOD in the PEF% < 80% group, 42 patients exhibited the therapeutic effectiveness after 3-day treatment, and the 3-day treatment efficiency rate was 48.84%. Among 27 patients that were diagnosed as CAOD in the PEF% > 80% group, 21 patients exhibited the therapeutic effectiveness after 3-day treatment, and the 3-day treatment efficiency rate was 77.78%. The difference of 3-day treatment efficiency rate between two groups was statistically significant (χ^2 = 6.98, P = 0.006) (**Table 3**). These results suggested that, compared with the CAOD patients with PEF% < 80%, the CAOD patients with PEF% ≥ 80% exhibited lower hospitalization rate, higher 3-day treatment efficiency rate and better short-term prognosis.

Relevance of PEF% and FEV1% in determining airway obstruction

In PEF% < 80% group, 75 patients were performed with the pulmonary function tests, among whom 65 patients exhibited FEV1% < 80%. In PEF% ≥ 80% group, 84 patients were performed with the pulmonary function tests, among whom 17 patients exhibited FEV1% < 80%. The correlation analysis showed χ^2 = 72.0 and P = 0.001 (**Table 4**). This indicated significant difference between two groups. The correlation coefficient r was 0.56. These results suggested that, PEF% and FEV1% exhibited the relevance in determining the existence of airway obstruction, and the correlation between them was strong.

Use of portable peak velocity self-monitoring meter

Among 329 patients, 277 patients agreed with the 3-day PEF monitoring after the diagnosis, and 83 patients correctly completed it, while 194 patients failed the monitoring. The correct completion rate was 29.96%, and the failure rate was 70.04%. This suggested that, few patients could properly use the portable peak velocity self-monitoring meter.

Relationship of airway hyper-responsiveness and CAOD

Among 83 patients who correctly complete the 3-day PEF monitoring, 22 patients exhibited

Table 3. Comparison of 3-day treatment efficiency rate of CAOD between two groups

Group	Effective after 3-day treatment (n)	Ineffective after 3-day treatment (n)	Total (n)	Effectiveness rate (%)
PEF% < 80%	42	44	86	48.84
PEF% ≥ 80%	21	6	27	77.78
Total	63	50	113	55.75
χ^2		6.98		
P		0.006		

Table 4. Relevance of PEF% and FEV1% in determining airway obstruction

PEF%	FEV1%		Total
	< 80%	≥ 80%	
< 80%	65	10	75
≥ 80%	17	67	84
Total	95	64	159
χ^2		72.0	
P		0.001	
r		0.56	

PEF variation rate ≥ 20% on the first day, and 61 patients exhibited PEF variation rate < 20% on the first day. Among 22 patients with PEF variation rate ≥ 20%, 19 patients were finally diagnosed with one of asthma, COPD and overlapping syndromes, with the diagnostic rate of 86.36%. Among 61 patients with PEF variation rate < 20%, 10 patients were finally diagnosed with one of asthma, COPD and overlapping syndromes, with diagnostic rate of 16.39%. The correlation analysis showed χ^2 = 31.81 and P = 0.006. (**Table 5**). These results suggested that, the patients with airway hyperresponsiveness by PEF monitoring should be highly suspected as CAOD, and performed with further active examination and treatment, while CAOD did not necessarily accompany with the airway hyperresponsiveness.

Relationship of early PEF variation rate monitoring and short-term prognosis

Among above 83 patients that correctly completed the 3-day PEF monitoring, 19 patients exhibited the PEF variation rate ≥ 20% on the first day and diagnosed as CAOD. Among them 15 cases were effective after the 3-day treatment, there were 12 patients that exhibited the PEF variation rate < 20% on the 3rd day. 4 cases were ineffective after the 3-day treat-

ment, there were 1 patient that exhibited the PEF variation rate < 20% on the 3rd day. The correlation analysis showed χ^2 = 4.188 and P = 0.021 (**Table 6**). These results suggested that, for patients with CAOD combined with airway hyperresponsiveness, the short term reduction of PEF variation rate down to 20% would indicate the effectiveness, namely the PEF variation rate monitoring in the early stage of treatment could predict the treatment efficacy.

Discussion

CAODs such as asthma, COPD, sleep apnea syndrome and COPD overlapping syndrome had become a common disease in China, and many patients had exhibited the late symptoms of pulmonary hypertensive chronic pulmonary heart disease when diagnosed, the patients' quality of life was low, and the treatment burden was heavy. The acute exacerbation of such diseases could affect the prognosis of patients, even certain literatures [10, 11] suggested that the risk of re-acute exacerbation towards the patients in the acute exacerbation stage of asthma or COPD within the next few months was much higher than those not in the acute exacerbation stage, if the subtle changes could be earlier detected before the acute exacerbation, the early treatment would inevitably reduce the numbers of acute exacerbation. Towards the above questions, some scholars proposed such methods as health assessment questionnaire and quality of life questionnaires, etc., and proposed that these methods exhibited good correlation with the objective examinations of lung functions [12]. Portable peak velocity meter could quickly measure PEF, with the advantages of simple operation and better patient's compliance. So this experiment was designed to study and identify the application values of portable peak velocity meter in diagnosing and treating CAOD.

PEF could reflect the patients' airway patency, and related with the patients' efforts, lung volume and respiratory muscle strength. The experiment excluded the patients that were affected by the latter three factors, so PEF

Table 5. Relationship of airway hyper-responsiveness and CAOD (on the first day)

Group	Diagnosed as CAOD (n)	Others (n)	Total (n)	Hospitalization rate (%)
PEF variation rate ≥ 20%	19	3	22	86.36
PEF variation rate < 20%	10	51	61	16.39
Total	29	54	83	34.94
χ^2		31.81		
P		0.006		

Table 6. Relationship of early PEF variation rate monitoring and short-term prognosis

Group	PEF variation rate < 20% on the 3rd day (n)	PEF variation rate ≥ 20% on the 3rd day (n)	Total (n)	Negative transferring rate (%)
Effective after 3-day treatment	12	3	15	80
Ineffective after 3-day treatment	1	3	4	25
Total	13	6	19	68.42
G		4.188		
P		0.021		

detection could directly reflect the situations of airway ventilation function. The results showed that, the peak velocity meter-detected PEF% < 80% or PEF variation rate ≥ 20% could quickly assist the diagnosis of CAOD, the hospitalization rate of CAOD patients with PEF% ≥ 80% was lower than those with PEF% < 80%, and the 3-day treatment was much more efficient than those with PEF% < 80%, the short-term prognosis was better. Among the CAOD patients with airway hyperresponsiveness, the negative transferring rate of PEF variation rate of the 3-day treatment effective group was higher than the 3-day treatment ineffective group, namely the changes of PEF variation rate could determine the therapeutic effects of CAOD. In short, PEF determination exhibited the confirmative roles in assisting the diagnosis, determining the short-term prognosis, and efficacy judgment, etc., consistent with some literatures [13]. In recent years, Shortness of Breath with Daily Activities (SOBDA) questionnaire might reflect the severity and prognosis of CAOD, and the clinical researches also exhibited good reliability and validity [14]. So the comparison of PEF and SOBDA needed to be further studied.

There literature suggested [15] PEF monitoring could find the mild condition changes of patients with asthma, earlier than the clinical symptoms. However, currently, PEF monitoring had not been the paid high attention by the doctors of grassroots hospitals and patients with asthma, in China, only 16% asthma patients had heard of peak velocity meter, and only 2% of them had the peak velocity meter [16]. Some foreign literature performed the statistics [17, 18] and revealed that there were only about 65% patients used the peak velocity meter to achieve the self-management. The experiment also found the similar problem, the rate of 3-day PEF variation rate monitoring that was correctly completed was significantly lower than the failure rate, proving that the self-monitoring ability of patients was not enough, and this was also one of the factors that CAOD was not managed and controlled well.

The airway hyper responsiveness referred to that because the trachea and bronchi were in the extremely sensitive state, some people would exhibit the excessive or premature reactions towards some stimuli (AHR/BHR). The determination of airway responsiveness was generally carried out by the bronchial stimulation test, but this test method had its limitations, might increase the risk of exacerbations, and not suitable for the general outpatient, emergent patient and community hospitals, while the PEF variation rate was a good indicator that could reflect the airway reactivity, and closely related to the bronchial stimulation tests [8]. Therefore, the application of peak velocity meter in monitored PEF variation rate could initially get the data of patient's airway reactivity.

FEV1 was an important indicator that could reflect the pulmonary function, with good reproducibility, and linearly correlated with the

degrees of airway obstruction. Though PEF exhibited relatively larger individual difference than FEV1, our findings suggested that PEF% had the strong relevance with FEV1% in determining the airway obstruction, with the correlation coefficient as 0.56, consistent with other literatures' reports (0.5-0.8), and also consistent with the results of this research that the peak velocity meter could quickly assist the diagnosis of COPD.

Meanwhile, the range PEF-3 peak velocity meter was 60-850 L/min, with error as ± 10% within 200-600 L/min, and the variation coefficient was Cv ≤ 5%, basically in line with the criteria of qualified peak velocity meter suggested by the National Asthma Education Program [19]. According to the statistics, the results of this peak velocity meter were similar to those of Wright peak velocity meter (UK) and English peak velocity meter, the reproducibility and reliability were good.

In short, the peak velocity meter could not only be used for the self-monitoring and disease condition assessment of asthma patients, but also be applied to other CAODs, it also had the effects of fast diagnosis, prognosis and treatment effects judgment. The meter could be simply sterilized and operated, and could be reused, even freely used in the emergency department or other places, providing the basis for the doctors' early diagnosis, so it would be equally important to enhance the consciousness of using peak velocity meter by doctors and patients.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Xiaofeng Tan, Department of General Internal Medicine, Tianjin Hospital, No. 406 Jiefangnan Road, Hexi Dist, Tianjin, China. E-mail: xiaofengtancn@163.com

References

[1] Masoli M, Fabian D, Holt S, Beasley R. Global Initiative for Asthma (GINA). The global burden of asthma: executive summary of the GINA Dissemination Committee report. Allergy 2004; 59: 469-478.

[2] Pachter LM, Weller SC, Baer RD, de Alba Garcia JE, Trotter RT 2nd, Glazer M, Klein R. Variation in asthma beliefs and practices among mainland Puerto Ricans, Mexican-Americans, Mexicans, and Guatemalans. J Asthma 2002; 39: 119-134.

[3] Vestbo J, Hurd SS, Agustí AG, Barnes PJ, Buist SA, Calverley P, Fukuchi Y, Jenkins C, Rodriguez-Roisin R, van Weel C, Zielinski J. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Respir Crit Care Med 2013; 187: 347-365.

[4] Cai BQ, Cai SX, Chen RC, Cui LY, Feng YL, Gu YT, Huang SG, Liu RY, Liu GN, Shi HZ, Shi Y, Song YL, Sun TY, Wang CZ, Wang JL, Wen FQ, Xiao W, Xu YJ, Yan XX, Yao WZ, Yu Q, Zhang J, Zheng JP, Liu J, Bai CX. Expert consensus on acute exacerbation of chronic obstructive pulmonary disease in the People's Republic of China. Int J Chron Obstruct Pulmon Dis 2014; 9: 381-395.

[5] Viegi G, Pistelli F, Sherril DL, Maio S, Baldacci S, Carrozzi L. Definition, epidemiology and natural history of COPD. Eur Respir J 2007; 30: 993-1013.

[6] GINA Report. Global Strategy for Asthma Management and Prevention 2006.

[7] Hayata A, Matsunaga K, Hirano T, Akamatsu K, Ichikawa T, Minakata Y, Ichinose M. Stratifying a risk for an increased variation of airway caliber among the clinically stable asthma. Allergol Int 2013; 62: 343-349.

[8] Sano T, Ueda H, Bando H. A preliminary study of PEFR monitoring in patients with chronic cough. Lung 2004; 182: 285-295.

[9] Vestbo J, Hurd SS, Agustí AG, Jones PW, Vogelmeier C, Anzueto A, Barnes PJ, Fabbri LM, Martinez FJ, Nishimura M, Stockley RA, Sin DD, Rodriguez-Roisin R. Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease. Am J Respir Crit Care Med 2013; 187: 347-365.

[10] Mapel DW, Schum M, Lydick E, Marton JP. A new method for examining the cost savings of reducing COPD exacerbations. Pharmacoeconomics 2010; 28: 733-749.

[11] Lane SJ, Petersen H, Seltzer JM, Blanchette CM, Navaratnam P, Allen-Ramey F, Fuhlbrigge A. Moderate symptom-based exacerbations as predictors of severe claims-based exacerbations in asthma. J Asthma 2013; 50: 642-648.

[12] Wilcox TK, Chen WH, Howard KA, Wiklund I, Brooks J, Watkins ML, Cates CE, Tabberer MM, Crim C. Item selection, reliability and validity of the Shortness of Breath with Daily Activities (SOBDA) questionnaire: a new outcome measure for evaluating dyspnea in chronic obstructive pulmonary disease. Health Qual Life Outcomes 2013; 14: 196.

[13] Li JT. Do peak flow meters lead to better asthma control? J Respir Dis 1995; 16: 381-398.

[14] Wilcox TK, Chen WH, Howard KA, Wiklund I, Brooks J, Watkins ML, Cates CE, Tabberer MM, Crim C. Item selection, reliability and validity of the Shortness of Breath with Daily Activities (SOBDA) questionnaire: a new outcome measure for evaluating dyspnea in chronic obstructive pulmonary disease. Health Qual Life Outcomes 2013; 11: 196.

[15] Kourtis G, Caiaffa MF, Forte C, Scarlato MI, Macchia L. Retrospective monitoring in the management of persistent asthma. Respir Care 2011; 56: 633-643.

[16] Lai CK, De Guia TS, Kim YY, Kuo SH, Mukhopadhyay A, Soriano JB, Trung PL, Zhong NS, Zainudin N, Zainudin BM. Asthma control in the Asia-Pacific region: the Asthma Insights and Reality in Asia-Pacific Study. J Allergy Clin Immunol 2003; 111: 263-268.

[17] Araújo L, Jacinto T, Moreira A, Castel-Branco MG, Delgado L, Costa-Pereira A, Fonseca J. Clinical efficacy of web-based versus standard asthma self-management. J Investig Allergol Clin Immunol 2012; 22: 28-34.

[18] Turner MO, Taylor D, Bennett R, Fitzgerald JM. A randomized trial comparing peak expiratory flow and symptom self-management plans for patients with asthma attending a primary care clinic. Am J Respir Crit Care Med 1998; 157: 540-546.

[19] Cressy DS, DeBoisblanc BP. Diagnosis and management of asthma: a summary of the National Asthma Education and Prevention Program guidelines. National Institutes of Health. J La State Med Soc 1998; 150: 611-617.