The Cost-Effectiveness of Mini Peak Expiratory Flow as a Screening Test for Chronic Obstructive Pulmonary Disease among the Bangkok Elderly†

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Abstract

This study aims to explore the cost-effectiveness of Mini Peak Expiratory Flow (miniPEF) as a screening test for Chronic Obstructive Pulmonary Disease (COPD) among the elderly in 124 urban communities around Siriraj Hospital, using the gold standard of diagnosis based on the guidelines of the Thoracic Society of Thailand. There were 3,094 subjects who participated and completed all the tests. The results showed that the cut-off miniPEF percentage of predicted value of highest average accuracy was 62 per cent. The sensitivity was 72.7 per cent (95% CI 67.0-78.6) and the specificity was 81.1 per cent (95% CI 79.7-82.5) The cost of screening 19 elderly to detect one case of COPD is 923 baht, with a false negative rate of 1.9 per cent (95% CI 1.3-2.5%) and a false positive rate of 17.5 per cent (95% CI 15.4-19.6%). It is suggested that measuring a miniPEF is regarded as one of the cost-effective screening tests for COPD in the elderly.

Key word : COPD, Elderly, miniPEF, Cost-effectiveness, Screening

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Our previous study has demonstrated the high prevalence and incidence of Chronic Obstructive Pulmonary Disease (COPD) among the Bangkok elderly[1]. The socio-economic impact of COPD is immense, and simply waiting until the affected individuals come to the attention of the health-care system is not an option. The cost-effectiveness of using a questionnaire as well as chest radiography (CXR) as screening tests for COPD have also been reported[2,3].

The European Respiratory Society (1995) has suggested routine spirometry as the gold standard for the early diagnosis of COPD[4]. Spirometry is accurate and valid but is expensive. Vaughan et al (1989) claimed good correlation between mini Peak Expiratory Flow Rate (miniPEF) and Peak Flow rate from a Peak Flow Meter (r = 0.85) as well as between miniPEF and $FEV_{1.0}$ (r = 0.74)[5]. Morrill CG et al (1981) confirmed that a miniPEF was reproducible and valid[6]. The cost-effectiveness of miniPEF as a screening test for COPD among the elderly has never been reported. This field study was the fourth part of the 11^{th} project of 16 projects under the megaproject of the Integrated Health Research Program for the Thai Elderly of the Faculty of Medicine Siriraj Hospital (IHRE) which aimed to identify the diagnostic criterion for COPD using miniPEF and the cost-effectiveness of miniPEF as a screening test for COPD in the elderly.

MATERIAL AND METHOD

This study was approved by the Ethics Committee on Human Rights involving Human Research. The design of the study was cross-sectional. Subjects were all 3,123 elderly aged 60 years and over residing in 124 urban communities within a radius of 10 km around Siriraj Hospital in January 1998, who were ambulatory and agreed to participate throughout the study. The exclusion criterion was the presence of respiratory symptoms from upper respiratory tract infection on the day of study.

The gold standard for diagnosing COPD was based on the Thoracic Society of Thailand guidelines [7]. The severity of COPD was defined as an $FEV_{1.0} \geq 70$ per cent, 50-69 per cent and less than 50 per cent of predicted value as mild, moderate and severe degree of airways obstruction respectively.

CXR and miniPEF were performed in the communities. Only data of those who completed mini PEF, and spirometry as well as a postero-anterior and lateral position CXR were analysed.

The miniPEF *via* mini Wright peak flow meter was selected from the best value of three acceptable values (Fig. 1). The measured value was then calculated as a percentage of predicted value (Gregg I 1965)[8].

Statistical analysis

The comparison between COPD and non-COPD subjects was performed using Chi-squared test for categorical variables and student's *t*-test for continuous variables. Statistical analysis included a receiver operating characteristic (ROC) curve with sensitivity and specificity. The statistical analysis was done *via* SPSS for windows version 9.05. A p-value of < 0.05 indicated a statistically significance difference between the groups. The theoretical cut-off percentage was at the best average accuracy and cost-effective cut-off percentage for screening survey at the lowest grand total cost.

A screening program with positive miniPEF test needs spirometry and CXR for confirmation of the diagnosis. The cost of a miniPEF test, spirometry and CXR were calculated from the material costs, equipments (depreciation), technician's salary and duration of the tests. As we regard Influenza as the main cause of acute exacerbation of COPD, the grand total cost consisted of diagnostic costs, false negative (F^-) costs for influenza treatment and the true positive (T^+) cost for influenza treatment was as follows :

$$\text{Cost for diagnosis} = [(T^+ + T^- + F^+ + F^-) \times 8.71] + [(T^+ + F^+) \times (92.4 + 80.65) \text{ baht}$$

whereas Cost of one miniPEF test = 8.71 baht
One spirometry = 92.40 baht
Two views of chest radiography = 80.65 baht

F^- cost = (Number of F^- x cost of influenza treatment by severity in non-vaccinated group)
$= (F^-_{mild} \times 1682) + (F^-_{moderate} \times 5726) + (F^-_{severe} \times 7765)$ baht

T^+ cost = (Number of T^+ x cost of vaccine) + {Number of T^+ x (1-efficacy of vaccine) x average cost of influenza treatment for vaccinated group}
$= (T^+ \times 248.4) + (T^+ \times 0.22 \times 354)$ baht

RESULTS

Out of 3,094 (99.1% of total) elderly subjects who completed spirometry, miniPEF and chest roentgenography, 220 cases had COPD according to the accepted definition. The characteristics of subjects (Table 1) showed the older, predominantly males, and more smokers in COPD group.

The cut-off percentage of predicted value at various sensitivities and specificities (Table 2) showed the cut-off percentage with the best average accuracy of 76.9 per cent was the miniPEF at 62 per cent of predicted value. This means that a miniPEF value less than or equal to 62 per cent is the criterion for diagnosing COPD that needs further confirmation with a gold standard method (spirometry and CXR).

The cost of miniPEF test was calculated from the cost of equipment (4 baht), technician's salary and duration of test (2 min) yields 5.24 baht as the cost of a miniPEF test of one elderly person.

Various cut-off percentage of predicted value of miniPEF at various severities of air flow obstruction are shown in Table 3. At a miniPEF of 62 per cent of predicted value there were 59 COPD detected of which 55 were mild and 4 moderate, with no severe cases.

From IHRE project No. 12 the additional annual cost per patient for mild, moderate and severe COPD was 1,682, 5,726 and 7,765 baht respectively (9). The lowest grand total cost (Table 4) was 316,049 baht at the cut-off per cent of 62 per cent of predicted value which surprisingly is the same cut-off per cent determined by theoretical consideration. For a screening program a cost-effective cut-off per cent demonstrated that those elderly individuals whose miniPEF was less than or equal to 62 per cent would be suspected of having COPD and needed gold standard method for confirmation of the diagnosis.

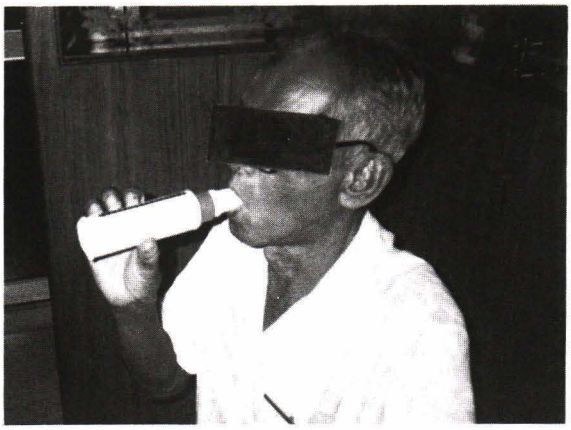

Fig. 1. Demonstrates the mini Wright Peak Flow Meter.

The decision tree (Diagram 1) shows the cost of 47.99 baht to screen one elderly person with mini PEF followed by the gold standard method for confirmation of the diagnosis.

The details of the cost-effectiveness of mini PEF as a screening method for COPD (Table 5) show the cost to screen 19 elderly to detect one COPD was 923 baht.

DISCUSSION

The efficacy of miniPEF at 62 per cent of predicted value according to the spirometry criteria based on $FEV_{1.0}/VC < 70$ per cent and irreversibility of < 15 per cent post bronchodilator change showed mild : moderate : severe severity were 55 : 4 : 0 consecutively. This means that at this cut-off percentage miniPEF can effectively detect mild airways obstruction. The cut-off percentage of miniPEF is the pre-

Table 1. Characteristics of COPD cases and non-COPD cases in the screening program.

	Population	COPD	Non-COPD	P-value*	Test
Number (cases)	3,094	220	2,874		
Age, mean ± SD (years)	67.9 ± 6.4	70.2 ± 6.7	67.7 ± 6.3	< 0.001	*t*-test
Sex (male : female)	0.6 : 1	2.6 : 1	0.6 : 1	< 0.002	χ^2
Smoker (%)	1,134 (36.6)	166 (75.5)	968 (33.7)	< 0.002	χ^2
Pack-year, mean ± SD	25.8 ± 24.4	32.8 ± 26.4	24.7 ± 23.8	< 0.001	*t*-test
Previous smoker (%)	449 (14.5)	64 (29.1)	385 (13.4)	< 0.002	χ^2
Current smoker (%)	685 (22.2)	102 (46.4)	583 (20.3)	< 0.002	χ^2
Non-smoker (%)**	1,959 (63.3)	54 (24.5)	1,905 (66.3)	< 0.002	χ^2

* COPD *vs* non-COPD, ** Tobacco smoking ≤ 0.5 pack-year

Table 2. Cut-off percentage of predicted values, sensitivity, specificity and average accuracy.

Cut-off percentage	Sensitivity	Specificity	Average accuracy
50	53.6	92.0	72.8
55	61.8	88.5	75.1
60	68.6	83.9	76.2
62	72.7	81.1	76.9
65	75.9	77.3	76.6
70	82.7	69.4	76.0
71	85.9	67.8	76.8
72	86.8	66.1	76.4
80	96.8	48.7	72.7
85	98.2	37.9	68.0

Table 3. Cut-off percentage and severity of COPD.

Z cut-off percentage	Severity of COPD (no. of cases) Mild	Moderate	Severe	Total
50	88	14	0	102
55	74	7	0	81
60	63	5	0	68
62	55	4	0	59
65	49	4	0	53
70	35	3	0	38
71	28	3	0	31
72	26	3	0	29
80	6	1	0	7

Table 4. Cut-off percentage, characteristics of test and cost of miniPEF screening test for COPD.

Cut-off percentage	Sen	Spf	T+	T-	F+	F-	Cost for diagnosis (baht)	Cost for influenza infection treatment		Grand total cost (baht)
								F^- cost (baht)	T^+ cost (baht)	
50	53.6	92.0	118	2,645	229	102	86,997	228,180	38,501	353,678
55	61.8	88.5	136	2,543	331	84	107,763	164,550	44,374	316,687
60	68.6	83.9	151	2,404	470	69	134,413	134,596	49,268	318,277
62	72.7	81.1	160	2,332	542	60	148,430	115,414	52,205***	316,049
65	75.9	77.3	167	2,222	652	53	168,677	105,322	54,489	328,488
70	82.7	69.4	182	1,994	880	38	211,728	76,048	59,383	347,159
72	86.8	66.1	191	1,901	973	29	228,379	64,274	62,320	354,973
80	96.8	48.7	213	1,401	1,473	7	318,711	60,910	69,498	449,119
85	98.2	37.9	216	1,089	1,785	4	373,222	15,818	70,477	459,517

Sen = sensitivity, Spf = specificity, T^+ = true positive, T^- = true negative, F^+ = false positive, F^- = false negative.

bronchodilator value. Therefore, in the screening of COPD case, the bronchodilator challenge process is not necessary. However, all the COPD and non-COPD subjects underwent a postbronchodilator miniPEF test. The mean $\pm$ SD of the percentage change of the mini PEF test post bronchodilator in COPD and non-COPD subjects were 9.85 $\pm$ 17.96 and 7.40 $\pm$ 23.70 per cent consecutively (p-value 0.13). It is noted that the standard deviation is very wide, therefore, the percentage change or reversibility cannot be applied. Infact, all those with a positive miniPEF test will undergo the spirometry later. The correlation between the pre-bronchodilator FEV1.0 and miniPEF was 0.768 (p-value 0.01) (Table 6). Vaughan et al (1989) showed a high correlation between miniPEF and FEV1.0 (r = 0.71[5] whereas our study revealed a higher correlation for both pre and post bronchodilator absolute value in both the COPD group and all subjects.

Badgett PG (1993)[10] suggested a PEF for diagnosing COPD using a cut-off percentage of 60 per cent of the predicted value with a sensitivity of 60 per cent and a specificity 97 per cent. The criterion for the diagnosis of COPD is a $FEV_{1.0}$/VC ratio < 60 per cent. Our study using diagnostic criterion of FEV1.0/VC ratio < 70 per cent, showed a sensitivity of 68.6 per cent (95% CI 62.5-74.7), and a specificity of 83.9 per cent (95% CI 82.5-85.3) at 62 per cent of predicted value. Our theoretical cut-off percentage is 62 per cent of the predicted value which gave a sensitivity of 72.7 per cent (95% CI 67.0-78.6) and specificity of 81.1 per cent (95% CI 79.7-82.5) which is suitable for a screening test. The cost to detect one case of COPD from 19 elderly individuals using the miniPEF as a screening method was 923 baht with a false negative rate of 1.9 per cent (95% CI 1.3-2.5) and a false positive rate of 17.5 per cent (95% CI 15.4-19.6). Its

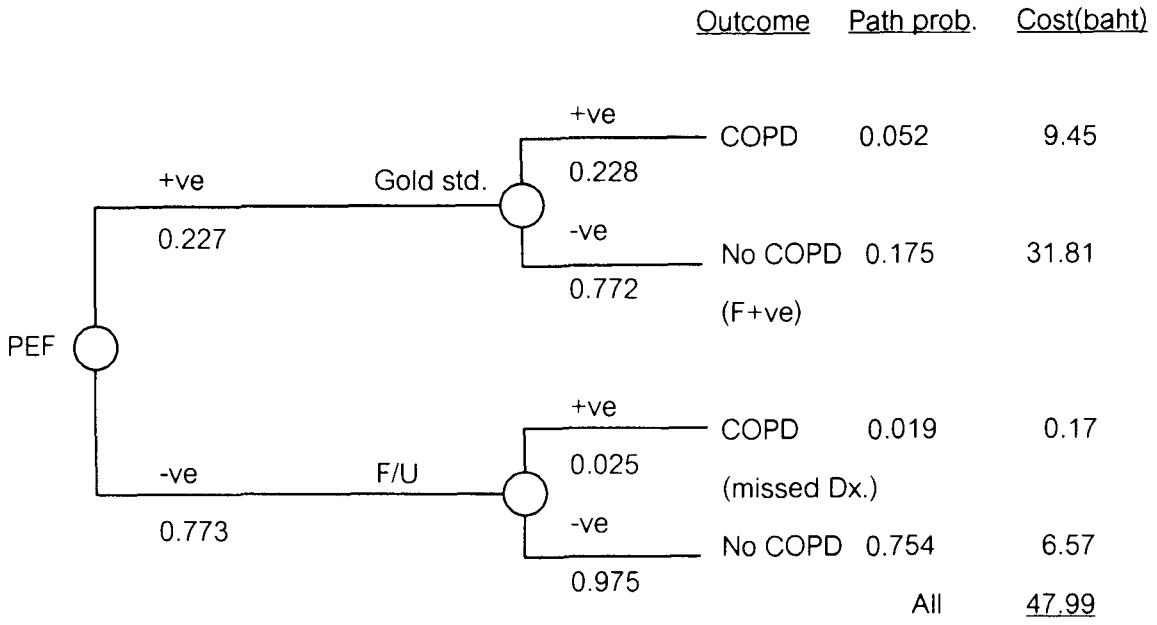

Diagram 1. Decision tree to detect COPD with miniPEF as initial test.

Table 5. The cost-effectiveness of miniPEF as screening method for COPD.

No. of cases detected for one screened subject	0.052	cases
Missed diagnosis or false negative	1.9	%
False positive	17.5	%
No. of subjects screened to detect one case of COPD	19.2	subjects
Cost to screen one subject	47.99	baht
Cost to detect one case of COPD	923	baht

Table 6. Correlation between absolute values of $FEV_{1.0}$ and miniPEF in the study.

	COPD group (n = 200)		r	Total subject (n = 3,094)		r
	$FEV_{1.0}$ (l)	MiniPEF (l/min)		$FEV_{1.0}$ (l)	MiniPEF (l/min)	
Prebronchodilator (mean ± SD)	1.36 ± 0.49	269.9 ± 111	0.813 (p = 0.01)	1.7 ± 0.48	352.8 ± 107	0.768 (p = 0.01)
Post bronchodilator (mean ± SD)	1.41 ± 0.51	289 ± 112	0.817 (p = 0.01)	1.76 ± 0.47	373 ± 109	0.732 (p = 0.01)

real efficacy might be of some value in the individual diagnosis of COPD.

It is suggested that the miniPEF test should be considered for COPD screening among the elderly in the community due to its cheap cost, and feasibility for use by a family physician. Nevertheless, it is necessary to identify the most cost-effective screening method for identifying cases of COPD.

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ประสิทธิภาพของมินิพีอีเอฟ ในการตรวจคัดกรองโรคปอดอุดกั้นเรื้อรังในผู้สูงอายุของชุมชน กรุงเทพ ฯ†

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รายงานนี้ได้ศึกษาผู้สูงอายุตั้งแต่ 60 ปีขึ้นไปใน 124 ชุมชน รอบโรงพยาบาลศิริราช เพื่อหาประสิทธิภาพของการตรวจหา mini Peak Expiratory Flow Rate (miniPEF) ด้วยเครื่อง Mini Wright Peak Flow Meter ในการตรวจคัดกรองเพื่อวินิจฉัยโรคปอดอุดกั้นเรื้อรัง โดยใช้มาตรฐานของการวินิจฉัยตามสมาคมอุรเวชช์แห่งประเทศไทย

มีผู้สูงอายุ 3,094 รายรับการตรวจครบทั้ง miniPEF, spirometry และ ภาพรังสีทรวงอก 2 ท่า (ท่าหน้า-หลังและด้านข้าง) ผลการศึกษา พบว่า miniPEF เท่ากับหรือน้อยกว่า 62% ของค่าปกติ ให้สงสัยเป็นโรคปอดอุดกั้นเรื้อรัง ซึ่งมีความไว 72.7% (95% CI 67.0-78.6) ความจำเพาะ 81.1% (95% CI 79.7-82.5) ความแม่นยำโดยเฉลี่ยดีที่สุด คือ 76.9% และเสียค่าใช้จ่ายเพื่อตรวจค้นโรคปอดอุดกั้นเรื้อรัง 1 ราย เป็นเงิน 923 บาทต่อการตรวจกรองผู้สูงอายุ 19 ราย มีผลลบเท็จ 1.9% (95% CI 1.3-2.5), ผลบวกเท็จ 17.5% (95% CI 15.4-19.6) คณะผู้วิจัยเชื่อว่าการตรวจ miniPEF เป็นวิธีที่ดีวิธีหนึ่งในการตรวจคัดกรองโรคปอดอุดกั้นเรื้อรังในผู้สูงอายุในชุมชน กรุงเทพ ฯ

คำสำคัญ : โรคปอดอุดกั้นเรื้อรัง, ผู้สูงอายุ, มินิพีอีเอฟ, ประสิทธิภาพ, การตรวจคัดกรอง

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