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A COMPARATIVE STUDY OF BEDSIDE PULMONARY FUNCTION TESTS AND SPIROMETRY IN STABLE COPD PATIENTS IN A TERTIARY CARE HOSPITAL OF SOUTH INDIA

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ABSTRACT

Introduction: Bedside pulmonary function tests are simple, reproducibleand can be performed even in sick, bedridden patients. This study was done to assess the roleof bedside pulmonary function tests, in patients with stable COPD and their comparison with standard spirometry.**Materials& Methods:**A cross sectional, observational study conducted on diagnosed out-patients of COPD in a tertiary care hospital.Spirometry,Oslen modified match test, Sabrazes single breath count,Sabrazes breath holding test, Forced expiratory time was done on all patients. Spirometry values were correlated with bedside tests. **Results:**Out of total 105 patients, 94 patients could not count >30 with single breath. This was correlated with spirometric values but not significant.26 patients who were able to hold breath for more than 25 seconds had positive correlation with spirometric parameters but not significant.81 patients had forced expiratory time of > 6 seconds, it was found to have positive correlation with the spirometric parameters, FEV1 actual (0.99 ± 0.19 L), FEV1 % predicted (33.29 ± 8.54 %), FVC actual (1.80 ± 0.36 L), FVC %predicted (47.29 ± 10.54%). This was statistically significant (P <0.01).

Conclusion: Forced expiratory time (FET) more than 6 seconds correlates with spirometric values and it can be proposed as surrogate marker for the assessment of lung function in clinically suspected COPD patients where spirometry is not feasible.

Key words: Bedside PFT, Spirometry, forced expiratory time

INTRODUCTION

Pulmonary function testing and in particular, spirometry is essential to establish a diagnosis of COPD.[1]Spirometry is an effort dependent procedure which requires optimal effort by the patient and is difficult to be done in sick bedridden patients. It is not available in all healthcare facilities .Various bedside pulmonary function tests like respiratory rate ,Oslen modified match test, [2]Sabrazessingle breath count ,[3]Sabrazes breath holding test ,[4]Forced expiratory time,[5]Wright's spirometers and pulse oxymetryhave been described in pulmonary diseases like obstructive airway diseases .These tests are simple ,reproducible ,requires no cost and can be performed even in sick ,bed ridden and oxygen dependent patients .In the COVID era when spirometry becomes difficult due to fear of infection transmission, bedside tests are alternative for easy and quick estimate of respiratory function. However there are only fewcomparative trials of spirometry with bedside pulmonary function tests .Hence we planned this study to assess the roleof bedside pulmonary function tests, in patients with stable chronic obstructive pulmonary disease and their comparison with standard spirometric parameters.

MATERIAL AND METHODS

This was a cross sectional, observational study conducted on diagnosed out-patients of COPD in Department of Respiratory Medicine at A J Institute of medical sciences,Mangalore a tertiary care teaching hospital over a period of 12 months. Purposive sampling technique was used.Based on the previous study [4] considering the percentage change in Single Breath Count (SBC) and Forced Expiratory Volume (FEV1) in patients who were able to successfully perform the test as 51%, the sample size was calculated with the following formula.

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$$n= \frac{Z_{(1-\alpha/2)}\}^2 P(1-P)}{d^2}$$

(n=required sample size, $Z^2_{(1-\alpha/2)}$ at α 0.05=1.96, P=Expected proportion change in two tests, d=Absolute precision: assuming the change to be 10%)
On substituting values,

n= 95.96 ~96 patients

Considering 10% dropout rate, the required sample size was 105 patients.

INCLUSION CRITERIA:
A) Diagnosed cases of COPD, bothold and newly diagnosed, according to GOLD guidelines 2020 [1]
B) Male and female patients aged above 40 years
C) Patients who present to OPD in stable condition
D) Patientswho are able to perform spirometry

EXCLUSION CRITERIA:
A) Those patients who are unable to perform technically correct spirometry
B) Acute exacerbation in last 4 weeks
C) Coexisting coronary heart disease or heart failure
D) Patients with concurrent structural lung diseases
E) Patients with terminal illness
F) Deaf patients
G) Patients who are unable to count or pronounce
H) Patients with chest wall deformities

Patient demographics and clinical details were collected.Spirometrywas done for all patients with EASY ONE PRO™ Lab machine. Bronchodilator reversibility test was performed.

Bedside pulmonary function tests were done, which include-

1) Olsen modified match test-

Patient was asked to blow the lit match stick at a distance of 3inch, 6inch and 9inch to check the ability to blow off the lit match stick.

2) Sabrazessingle breath count-

Patients was asked to hold the deep breath and asked to count numbers till the next breath.The number at which the patient stops counting will be noted.

3) Sabrazes breath holding test-

Patient was asked to take full breath and hold it as long as possible; the time period in seconds is noticed.

4) Forced Expiratory Time (FET)-

After deep breath to total lung capacity, patient is asked to exhale maximally and forcefully with an open mouth & stethoscope is kept over trachea and number of seconds noted till no breath sound is heard. Test is repeated three times and mean of three readings is taken.

Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were correlated with above 4 bedside tests

STATISTICAL METHODS

Data was entered in Microsoft excel. Continuous variables were reported as mean and standard deviation. Categorical variables werereported as percentages.Chi square and unpaired t test was used to assess differences in categorical and continuous variables. Pearson's correlation was reported to find out the significance among the two different investigation results. P value <0.05 was considered statistically significant.Medcalc 16.4 version software was used for all statistical analysis

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RESULTS

Out of total 105 patients, 92 patients were male and 13 patients were female. Age distribution of study subjects showed that whole study population was more than 40 year age group. However maximum number of patients were in age group of 61-70 years (n = 70). Mean age of the study population was 64.66 ± 6.05 years; it was 64.87 ± 6.321 for males and 63.231 ±3.395 for females.

Table 1: Age and Sex Distribution of the Study Population

Age (years)	Male	Female	Total
40 -50	5 (5.43)	0	5 (4.76)
51 – 60	15 (16.30)	4 (30.77)	19(18.10)
61 – 70	61 (66.30)	9 (69.23)	70 (66.67)
71 – 80	10 (10.87)	0	10 (9.52)
>80	1(1.09)	0	1(0.95)
Total	92(87.62%)	13(12.38%)	105(100%)

In our study group mMRC grading of breathlessness was done in all patients. Majority of the study population (n = 50) were having grade 2 mMRC level of physical limitation, followed by grade 3 (n = 43) and remaining were having grade 1(n = 12) mMRC level of physical limitation. However, none of the patients had grade 0 and grade 4 level of physical limitation. Mean mMRC level of study population was 2.5 + 0.664.

Table 2: mMRCdyspnea scale

mMRC Grade	No of Cases = 105	Mean and SD of the Total Population
0	0	2.5±0.664
1	12 (11.43)	
2	50 (47.62)	
3	43 (40.95)	
4	0	

In our study the 31 patients had a FEV1 percentage predicted value of less than 30 with a mean of 24.77 + 4.014. Forty five patients had FEV1 percentage predicted value ranging between 31 to 40 percent with a mean of 35.04 + 2.68.Twenty three patients had FEV1 percentage predicted value ranging between 41to 50 had a mean of 45.52+2.92.Four patients had FEV1 percentage predicted value ranging between 51to 60 with a mean of 56.75+2.87. Two patients had FEV1 percentage predicted value more than 60 and a mean of 62.

Table 3: Mean spirometric parameter (FEV1 percentage predicted) of the study population

FEV1 percentage predicted value	Number of patients	Mean and SD
<30	31	24.77±4.014
31-40	45	35.04±2.68
41-50	23	45.52±2.92
51-60	04	56.75±2.87
>60	02	62

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In our study all 105 patients were able to blow the matchstick at a distance of 3 inch, 6 inch and 99 patients were able to blow matchstick at a distance of 9 inch remaining 6 patient could not blow .

Table 4: Olsen Modified Match Test Conducted in Our Study Population

Olsen Modified Match Test	Number of Patients
Able to blow at distance of 3 inch	105 (100%)
Able to blow at distance of 6 inch	105 (100%)
Able to blow at distance of 9 inch	99 (94.29%)

In our study population 94 patients had ability to count less than 30 with a mean of 19.12 + 4.98 and 11 patients could count more than 30 with a mean of
37.18 + 2.05.

Table5: Mean Sabrazes Single Breath Count of the Study Population

Mean Sabrazes Single Breath Count	Number of Patients	Mean and SD
< 30 counts	94	19.12± 4.98
>30 counts	11	37.18±2.05

In our study population 22 patients had ability to hold breath for more than 25 seconds with a mean of 28.77+3.66. Fifty seven patients had ability to hold breath between 15 to 25 seconds with a mean of 19.28 + 4.69 and 26 patients had ability to hold breath for less than 15 seconds with a mean of 12.47 + 1.94.

Table 6: Mean Sabrazes Breath Holding Test of the Study Population

Sabrazes Breath Holding Test (seconds)	Number of Patients	Mean and SD
>25	22	28.77±3.66
15 – 25	57	19.28±4.69
<15	26	12.47±1.94

In our study 24 patients had forced expiratory time of less than 6 seconds with a mean of 5.79 + 0.658 and 81 patients had FET of more than 6 seconds with a mean of 8.73 + 2.11.

Table 7: Mean Values of Forced Expiratory Time of the Study Population

FET	Number of patients	Mean and SD
< 6 s	24	5.79±0.658
>6 s	81	8.73± 2.11

In our study 94 patients could not count more than 30 at single breath. This was correlated with spirometric values of FEV1 actual (1.04 ±0.27 L), FEV1 % predicted (34.78±9.49%), FVC actual (1.88 ± 0.49 L), FVC % predicted (49.15 ± 12.68 L); all had positive correlation except FVC % predicted value. This was not statistically significant. On correlation it was observed that that those patients who cannot count more than 30 had maximum FEV1 percentage predicted not greater than 44.27%, FVC percentage predicted not greater than 77.53%. 11 patients were

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found to have ability to count more than 30 at one breath and found to have poor correlation with of FEV1 actual (1.33 ± 0.28 L) , FEV1 % predicted (43.09 ± 10.24%), FVC actual (2.31 ± 0.64 L), FVC %predicted (59.45 ± 18.08 %).

Table 8: Correlation betweenSabrazes single Breath Count and Spirometric Parameters

Bedside PFT	Number of Counts Per Breath	Spirometric	Mean±SD	R^2
Single breath count	< 30 (N= 94)	FEV1 Actual	1.04 ±0.27	0.14
		FEV1 % Predicted	34.78 ± 9.49	0.007
		FVC Actual	1.88 ± 0.49	0.09
		FVC % Predicted	49.15 ± 12.68	-0.04
	>30 (N=11)	FEV1	1.33 ± 0.28	-0.07
		FEV1 % Predicted	43.09 ± 10.24	-0.35
		FVC Actual	2.31 ± 0.64	-0.17
		FVC % Predicted	59.45 ± 18.08	-0.34

In our study, 22 patients were able to hold breath for less than 15 seconds and found to have poor correlation with spirometricparameters, FEV1 actual (0.95 ± 0.19 L) , FEV1 %predicted (32.96 ± +9.35 %) FVC actual (1.62 ± 0.36 L), FVC %predicted (44.27 ± 11.28 %), FEV1% (58.77± 8.04). However none of the patient with breath holding capacity of less than 15 second had FEV1 percentage predicted greater than 42.3.Fifty seven patients were able to hold breath between 15 to 25 sec and were found to have also poor correlation with spirometric parameters, FEV1 actual (1.09 ± 0.30 L), FEV1 %predicted (35.12 ± 9.88 %), FVC actual (1.98 ± 0.52 L), FVC %predicted (50.25 ± 13.46%).But 26 patients who were able hold breath for more than 25 seconds had positive correlation with spirometric parameters, FEV1 actual (1.17 ± 0.28 L) , FEV1 %predicted (40.18 ± 9.26 %) FVC actual (2.14 ± 0.55L), FVC %predicted (57.22 ± 13.69 .This was not statistically significant.

Table 9: Correlation BetweenSabrazes Breath Holding Test and Spirometric Parameters

Bedside PFT	Time duration n = number of patients	Spirometric parameters	Mean ± SD	R^2
Breath holding test	< 15 sec (n=22)	FEV1 Actual	0.95 ± 0.19	-0.09
		FEV1 % Predicted	32.96 ± 9.35	-0.54
		FVC Actual	1.62 ± 0.36	0.08
		FVC% Predicted	44.27 ± 11.28	-0.43
	15 - 25 sec (n=57)	FEV1 Actual	1.09 ± 0.30	-0.05
		FEV1 %Predicted	35.12 ± 9.88	-0.05
		FVC Actual	1.98 ± 0.52	-0.08
		FVC %Predicted	50.25 ± 13.46	-0.08
	>25 sec (n=26)	FEV1 Actual	1.17 ± 0.28	0.31
		FEV1 %Predicted	40.18 ± 9.26	0.20
		FVC Actual	2.14 ± 0.55	0.34

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		FVC %Predicted	57.22 ± 13.69	0.27

In our study all 105 patients were able to blow the match stick at a distance of 3 inch, 6 inch and found to have poor correlation with spirometric parameters, whereas 99 patients who were able to blow match stick at 9 inch distance also found to have poor correlation with spirometric parameters.

Table 10: Correlation Between Olsen Match Blow Test and Spirometric Parameters

Bedside PFT	Distance	Spirometric parameters	Mean ± SD	R^2
Blow test	3 inch (n =105)	FEV1 Actual	1.05 ± 0.28	-0.13
		FEV1 %Predicted	35.65 ± 9.86	-0.02
		FVC Actual	1.92 ± 0.52	-0.22
		FVC %Predicted	50.23 ± 13.61	-0.11
	6 inch (n = 105)	FEV1 Actual	1.07 ± 0.28	-0.14
		FEV1 %Predicted	35.64 ± 9.86	-0.03
		FVC Actual	1.93 ± 0.52	-0.22
		FVC %Predicted	50.23 ±13.61	-0.11
	9 inch (n = 99)	FEV1 Actual	1.08 ± 0.29	-0.13
		FEV1 %Predicted	35.70 ± 10.05	-0.11
		FVC Actual	1.95 ± 0.52	-0.02
		FVC %Predicted	50.60 ±13.77	-0.11

In our study 81 patients had forced expiratory time of more than 6 seconds, it was found to have positive correlation with the spirometric parameters, FEV1 actual (0.99 ± 0.19 L) , FEV1 % predicted (33.29 ± 8.54 %), FVC actual (1.80 ± 0.36 L), FVC %predicted (47.29 ± 10.54%). This was statistically significant (P <0.01). 24 patients had forced expiratory time of less than 6 seconds and found to have spirometric parameters, FEV1 actual (1.09 ± 0.30 L) , FEV1 %predicted (36.35 ± 10.16%),FVCactual(1.9±0.55 L), FVC %predicted (51.09 ± 14.33%).

Table 11: Correlation Between Forced Expiratory Time and Spirometric Parameters

Bedside PFT	Duration (seconds)	Spirometric parameters	Mean ± SD	R2
Forced Expiratory Time	< 6 (n = 24)	FEV1 Actual	1.09 ± 0.30	0.43
		FEV1 Predicted	35 ± 10.16	0.27
		FVC Actual	1.96 ± 0.55	0.48
		FVC Predicted	51.09 ± 14.33	0.34
	>6 (n = 81)	FEV1 Actual	0.99 ± 0.19	0.25
		FEV1 Predicted	33.29 ± 8.54	0.56
		FVC Actual	1.80 ± 0.36	0.01
		FVC Predicted	47.29 ± 10.54	0.39

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DISCUSSION

In the original description of Oslen modified match test,if a person can blow a match stick at distance of 9 inch,6 inch and 3 inch will have maximum breathing capacity of > 150L/min,>60 L/min and >40L/min respectively .Aland RS et al[35] assessed the correlation of this test and found poor correlation with standard spirometry results.In our study group, 99 patients out of 105 were able to blow a match stick at a distance of 9 inch, and all 105 patients were able to blow a match stick at both 6 inch and 3 inch distance. In a simplified message one can assume that if a person is unable to blow out the match stick at a distance of 9 inch, it is reasonable to observe FEV1 actual is below 900 ml, as only one out of 6 patients had FEV1 of 1100 ml, rest all 5 patient have FEV1 of < 900ml which is reasonably specific but not sensitive. Therefore ability to blow the match stick at a distance of 9 inch can be considered reasonably specific but lacks sensitivity, hence interpretation of this is not very clear and one cannot draw a water tight line that a particular person who is able to blow the candle at a distance of 9 inch will have or is associated with given amount of FEV1 of more than 900 ml, similar level of overlap was observed in FVC and FEV1/FVC ratio.

Bartfieldet al[7] assessed the correlation of single breath counting (SBC) and peak expiratory flow rate (PEFR) to forced expiratory volume in the first second (FEV1). The correlation of SBC to FEV1 was slightly better than PEFR to FEV1 (r=.66 versus r=.62). SBC was also found to correlate well with PEFR (r=.68). SBC is a reasonable alternative to PEFR. Thirty to forty is considered to be normal in average individual, in our study the patients who were able to count more than 30 at single breath found to have positive correlation with spirometricvalues.On correlation it was observed that that those patients who cannot count more than 30 had maximum FEV1 of 1300 ml, and about 5 patients out of 11 patients who were able to count more than 30 had FEV1 below 1300 ml, hence one can assume that patient who is not able to count more than 30 have FEV1 actual of 1300 ml in stable COPD patients. Hence it is reasonably specific for FEV1 of 1300 ml but again it lacks sensitivity. Aland RS et al[6] assessed the same and showed similar results which lacks sensitivity.

In our study about 22 patients were able to hold breath for less than 15 seconds and found to have poor correlation with spirometric values .57 patients were able to hold breath between 15 to 25 sec and were found to have poor correlation with spirometric values. 26 patients were able hold breath for more than 25 seconds, when correlated with spirometric values all found to correlate positively to BHT. Aland RS et al[6] studied the correlation between this test and spirometric values and found poor correlation.Hence breath holding test ability of less than 15s is reasonably specific for FEV1 of 1140 ml but lacks sensitivity.

Airflow limitation is caused by a mixture of small airway disease and parenchymal destruction, and is enhanced during forced expiration due to passive collapse of the peripheral airways induced by positive pressure in the thoracic cavity. Airflow limitation in forced expiration suggests the presence of airway obstruction and with loss of elastic recoil in COPD.[1]Lalet al[5] studied the relation between a clinical estimate of forced expiratory time (FET) and other measurements such as FEV_1/FVC ratio and PEFR. The results showed that airway obstruction can be confidently diagnosed or excluded by accepting the following major subdivisions: an FET of less than 5 seconds with air-flow having stopped suggests an FEV_1/FVC ratio of more than 60%; an FET of more than 6 seconds represents an FEV_1/FVC ratio of less than 50% or if the air-flow continues an FEV_1/FVC ratio of less than 40 %.

Aggarwal A N et al[8] studied diagnostic characteristics and clinically useful threshold of FET as a screening tool for identifying airway obstruction and to substantiate the diagnostic utility of FET through a systematic review of literature. They concluded FET of 5 seconds or more rather than the commonly recommended threshold of 6 seconds should be regarded as abnormal .In our study 81 patients had forced expiratory time of more than 6 seconds, it was found to be positive correlation with the spirometric values which is statistically significant (p value <0.01).

Kern David et al[9] studied auscultated forced expiratory time as a clinical and epidemiological test of airway obstruction and concluded that although FET is a simple ,inexpensive and fairly reproducible test ,it cannot be recommended as an epidemiological tool because of its low specificity .FET was proposed more than 50 years ago. The test is simple to perform ,requires no additional infrastructure ,can be easily added to routine patient examination without consuming much time and provides results comparable to the time calculated on spirometry .It has good reproducibility and correlates well with other measures of airflow limitation.

CONCLUSION

Forced expiratory time (FET) more than 6 seconds correlates with spirometric values and it can be proposed as surrogate marker for the assessment of lung function in clinically suspected COPD patients where spirometry is not feasible.

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Limitations

- Relatively small sample size
- Study done on stable ambulatory COPD patients and did not include bedridden patients

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