Original Research Article

Correlation of breath holding time with spirometry test - An alternative non technician dependent surrogate test for spirometry

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Abstract

Study objective: To determine the correlation of breath holding time with standard measures post bronchodilator FEV1, FVC, FEV1/FVC ratio and PEFR. **Materials and Methods: Design:** Prospective observational study. **Setting:** Smt Kahibai Navle Medical College and General Hospital, Pune. **Time duration:** January 2017 - June 2017. **Participants:** 499 cases, which included 100 normal volunteer and 399 participants who needed to undergo spirometry for clinical indications. Spirometry (Easy one, ndd) was performed on all the study participants. Post bronchodilator FEV1, FVC, FEV1/FVC ratio and PEFR were measured and recorded. Then participants were subjected to Breath Holding time test. All participants were then classified as normal, obstructive or restrictive disease on the basis of spirometry and clinical findings. The results of Breath Holding Time test were then correlated with post bronchodilator FEV1, FVC and PEFR. **Conclusion:** Breath holding time correlated well with post bronchodilator FEV1, FVC and PEFR in normal, obstructive and restrictive patients however the correlation was weak with PEFR. In resource poor settings BHT can be a reasonable non technician, non-machine dependant alternative to Spirometry.

Key Words: BHT-breath holding time, FEV1-Forced Expiratory Volume in one second, FVC-Forced Vital Capacity PEFR- Peak Expiratory flow rates.

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INTRODUCTION

After the invention of spirometry by John Hutchinson it has become the most commonly used procedure for evaluation of pulmonary functions.[1] Spirometry may be indicated[2]:

1. To measure the effect of disease on pulmonary function
2. To screen individuals at risk of having pulmonary disease
3. To assess pre-operative risk.
4. To assess health status before beginning strenuous physical activity programmes.
5. To assess therapeutic intervention and prognosis
6. To monitor people exposed to injurious agents
7. To monitor for adverse reactions to drugs with known pulmonary toxicity
8. Disability/impairment evaluations
9. To assess patients as part of a rehabilitation programme
10. To assess risks as part of an insurance evaluation
11. To assess individuals for legal reasons

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Spirometry is performed by asking the patient to inhale maximally and then exhale forcible in the instrument. This instrument is connected to computer which depicts the graph and calculate the flow and the volumes of the exhaled air. Performing this test can be sometimes cumbersome as this test requires:

- Spirometer to be held firmly in the lips and the mouthpiece to be kept over the tongue preventing any leakage and to blow out maximum. Patients need to have a good cognitive function to follow the commands given by the instructor and synchronise with the machine while blowing.
- It is a time consuming test. Patients get fatigued due to repetitive manoeuvre and many a times needs rescheduling which further increases the cost of health care.
- Repeated calibration and leakage check could be needed for some Spirometers
- Setup for checking temperature, humidity and printing the results.
- A motivated technician to check the machine regularly, familiarise the patient with the test protocol and to instruct the patient regarding synchronization with the machine.
- Maintenance of the machine and the computer.

Cander and Comroe listed desirable characteristics of office pulmonary function equipment roughly as follows:[3, 4]

- The test should be rapid, simple and requiring aminimumcooperation and understanding of patient
- Equipment should be inexpensive. It should not require highly trained technicians.
- The test should not cause fatigue and should allow for several determinations.
- Equipment should preferably be portable and easy to clean.

Many a times, we encounter patients who are either not in a clinical condition to perform the test or are not able to comply with the machine and the instructions given while performing the test. Sometimes the machine can run into technical problems, or might get out of calibration and at times the technician is not available.

In these situations, we seek for alternative methods to assess pulmonary function. Various ancient bed side pulmonary function tests used by our ancestors were:[5]

1. Seberese's breath holding test:
2. Seberese's Single breath count:
3. Schneider'smatch blowing test
4. Greene and Berowitz cough test:
5. Tracheal auscultation/ Forced expiratory time
6. De Bono's whistle blowing Test
7. Peak flow meter
8. Bedside pulse oximetry
9. Arterial blood gases

We selected Seberese's breath hold test to compare with standard spirometry. Earliest note on the significance of Breath holding test as a marker of cardiopulmonary function was made by Sarbare's of Bordeaux[6]. He found the average normal voluntary apnoeic interval (between breaths) while tidal breathing to be from 20 to 25 seconds in duration; while an interval of 30 to 35 seconds was exceptional.[6] However on deep inspiration apnoeic interval of more than 40 seconds is normal; between 20 and 40 seconds reflects compromised cardiopulmonary reserve; less than 20 seconds indicates very poor cardiopulmonary reserve.[7] A single breath count of less than 15 indicates severe impairment of vital capacity.[7] The maximal duration of voluntary apnea varies from subject to subject and depends on chemical and non-chemical stimuli .The amount of time a person can hold his breath is influenced by the PO2, PaCO2 and lung volume[8]. PO2 of the gas breathed markedly influence the duration of breath holding and the rate of pulmonary diffusion of oxygen. Anxiety can reduce the duration of breath holding. So it is important to relax the subjects before performing the test.

Instructions given by Yandell Henderson to perform breath holding test are:[6]

1. Sit quiet for 5 minutes.
2. Take a full but not too deep breath
3. Hold it with mouth and nostrils closed
4. Note time in seconds.

There are several advantages of breath holding time. The breath-holding test is simple and rapid. The simplest objective measure of breath-holding is its duration. Unlike spirometry there is no mouth piece, no concern about contamination of the equipment or transmission of contagious disease, no specialized breathing techniques.

MATERIALS AND METHODS

Type of the study: prospective observational study

Inclusion Criteria

1. All patients above the age of 12 years who need to undergo spirometry for clinical indications.
2. 100 volunteers above the age of 12 years with normal spirometry test results.

Exclusion Criteria

1. Patients who were unwilling to participate in the study.
2. Patients whose spirometry was not acceptable and valid as per ATS standard of Spirometry(2)
3. Patients who have absolute or relative contraindication for spirometry
4. Myocardial infarction within the last month
5. Conditions that can lead to a suboptimal test:

6. Chest, abdominal, facial, oral pain
7. Stress incontinence
8. Dementia, confusion
9. active pulmonary tuberculosis,
10. Acute exacerbation of COPD,
11. Acute severe asthma and haemoptysis

Methodology: Each participant was screened by general physical and systemic examinations. A detail history was taken for smoking, occupational, indoor pollution, recent illness and medication used. The participants who qualified were taken for spirometry. Anthropometry was done by measuring weight in kilogram (Kg) with indoor clothing without shoes on a weighing machine; standing height was measured without shoes by a Harpenden's stadiometer. In all subjects, spirometry was done from 9AM to 11AM under the ambient temperature and humidity, to avoid bio variability due to diurnal rhythm. Easy one, ndd spirometer was used for conducting the study. Spirometry was performed in sitting position, with a nose clip attached. The ATS guidelines for spirometry were followed.[(2)]Broncho dilation was achieved using a pMDI salbutamol 400 microgram (4 puffs of 100 microgram each) given through a valved spacer. Best of three successive test readings was taken as final result and the primary values, i.e. post bronchodilator forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), peak expiratory flow rate (PEFR)were noted. Then single Breath holdingtime was performed by all participants within 3 minutes to avoid the waning effect of bronchodilator. Participants were asked to hold the breath after a normal tidal volume breath, till the breaking point. Breath Hold Test manoeuvre was performed 3 times with a gap of 5 minutes and the best of the 3 values were included for analysis.

Stastical Analysis: All data analyses were performed using SPSS statistics for Windows version 20.0 (Armonk NY: IBM Corp). Spearman correlation coefficients was used for comparing between Single Breath Count, Breath Hold Time, post bronchodilator FEV1, FVC, FEV1/FVC ratio and PEFR. The correlation coefficient were evaluated by Spearman's rho test. P value of less than 0.05 was considered to be significant as the distributions were normal.

RESULTS

Study was conducted on total 499 participants which were divided into groups of Normal, restrictive and Obstructive based on the spirometry data. There were 100participants with normal spirometry and they were between the age group 12 year- 84 year with average age of 47.9± 15.9years. Out of 100 normal participants, 64 were male and 36 were females. 136 participants were found to be having restrictive pattern on spirometry, out of which 60 were males and 76 were females. The average age of participants in restrictive group was 47.8 ± 16.7 year with range ranging 12 year- 80 years. 263 participants had obstructive spirometry out of which 162 were males and 101 females, these participants were ranging from 12year to 87 years of age, with average age of 53.2year ± 16year.

Table 1:

Characteristics	Normal/ control(n=100)	Obstructive (n=263)	Restrictive(n=136)
Age (years)	47.9± 15.9	53.2 year ± 16	47.8 ± 16.7
Male	64	170	86
Females	36	93	50
Smokers	42	109	26

The Mean actual FEV1 in normal individuals was 2.402±0.789 litre, 1.274±0.626 litres in patients having obstructive airway disease and 2.808±0.706 litres in patients having restrictive spirometry. It was observed that Mean FEV1 levels were least in patients having obstructive airway disease. The difference in the mean values was statistically significant. The Mean FVC values were 2.87±0.89 liters in normal individuals, 2.10±0.81 liters in patients having obstructive disease and 2.08 ±0.81 liters in patients having restrictive spirometry. It was found that patients with obstructive airway disease have a significant reduction in the FVC, FEV1 and FEV1/FVC% ratio as compared to the restrictive and normal individuals. Patients having restrictive spirometry had a significant reduction in FVC as compared to normal volunteers. Mean PEFR was 4.96 ±2.02 litres in normal subjects, 3.18 ±5.76 litres in patients with obstructive spirometry and 4.33 ± 1.92 litres in patients with restrictive spirometry .It was observed that Mean actual PEFR was least inpatients having obstructive disease. However the variation was maximum in these patients and the difference was statistically significant. It was also noted that PEFR percent prediction was only 40% in obstructed patients, more than 60% in normal and restricted patients and the difference was statistically significant. The range of breath hold time was 8-94 for normal individuals, 2-92 for restrictive patients and 5-100 for obstructed patients.

Table 2: Breath Hold Time

		Breath Hold Time	
	N	Mean	StdDev
Normal	100	34.5612	18.7441
Obstructive	263	28.9198	16.9882
Restrictive	136	28.3955	14.8385
Total	**499**	**F= 4.79, P< 0.009**	

The mean breath hold time did not differ significantly with respect to type of patients. Further analysis was done to find correlation of breath hold with post bronchodilator FEV1, FVC and PEFR.

Table 3: Correlation of spirometry with other parameters

Variable	FEV1		FVC		PEFR	
	R	t	r	t	r	t
normal	0.455	5.04	0.447	4.92	0.378	4.03
restrictive	0.392	4.98	0.366	4.59	0.316	3.87
obstructive	0.438	7.91	0.446	8.09	0.138	2.26

r= spearman's coefficient of correlation, t = test for finding significance of correlation

Breath holding time was significantly correlated with post bronchodilator FEV1, FVC and PEFR in all three groups. Though breath hold time was significantly related with post bronchodilator FEV1 and FVC, correlation was not significant with PEFR in obstructive group of patients.

Table 6: Categorization of breath hold time and its correlation with FEV1

Group	Mean FEV1	Standard deviation	Minimum FEV1	Maximum FEV1
Normal				
less than 20	1.63	0.28	1.35	1.91
20-35	2.16	0.7	1.46	2.86
36-50	2.52	0.68	1.84	3.2
51-65	3.01	0.71	2.3	3.72
66-80	3.1	0.78	2.32	3.88
more than 80	3.3	0.66	2.64	3.96
Obstructive				
less than 20	1.26	0.62	0.64	1.88
20-35	1.19	0.63	0.56	1.82
36-50	1.73	0.62	1.11	2.35
51-65	2.2	0.62	1.58	2.82
66-80	2.9	0.62	2.28	3.52
Restrictive				
less than 20	1.35	0.7	0.65	2.05
20-35	1.9	0.71	1.19	2.61
36-50	2.13	0.7	1.43	2.83
51-65	2.35	0.66	1.69	3.01
66-80	2.42	0.68	1.74	3.1

DISCUSSION

A number of patient -related factors have been implicated in the development of post-operative respiratory complications. They include the presence of chronic lung disease (particularly obstructive airway disease), patient's overall state of health , age, history of cigarette smoking and the presence of comorbid conditions including malnutrition , congestive heart failure, alcohol use, functional dependence, and impaired sensorium. The reported incidence of post-operative pulmonary complications in patients with COPD varies from 10% to greater than 50% and is influenced by type of surgery , magnitude of pre-existing respiratory impairment , and criteria used to define complications. Reversible obstruction should be corrected before operation. This can be accomplished best by postponing the operation and employing the therapeutic measures to be outlined later in this discussion. According to SCHWABER JR, all but emergency life-saving surgery should be avoided or delayed when properly performed pulmonary function tests reveal a vital capacity below 1 litre, a timed vital capacity below 500 ml. in the first second, or maximum expiratory flow rate below 100 litres per minute.[08] Fuso L, Cisternino L, Di Napoli A, et al postulated that, the risk for post-operative respiratory complications appears to increase significantly when the FEV1 is below 65% of predicted.[09] Hence an attempt was taken to find out the limits of Saberse breath hold test and FEV1 levels to evaluate the functional correlation between these tests and to set the limits for preoperative evaluation. The single breath hold was arbiterly divided and the mean value and range was calculated from the data. In patients with severe disease, an important issue is whether a critical level of lung function exists below which the risk of developing a major, potentially life-threatening pulmonary complication is so high as to make anesthesia and surgery too dangerous. In the past, such a prohibitive threshold or level was proposed. Subsequent studies by William s CD, Brenowitz JB however, have failed to support this hypothesis.[10] Milledge JS, Nunn JF found that patients with an FEV1 as low as 450 mL have been found to tolerate surgery safely. Hence, patients should not be denied necessary operative procedures solely on the basis of marginal lung function. As with all medical interventions, the potential benefits of the operative procedure must be weighed against the operative risk.[11] We have correlated Breath holding time with post bronchodilator FVC, FEV1, and PEFR& FEV1/FVCratio in all three groups. Single breath holding have positive correlation with post bronchodilator FEV1 and FVC and PEFR. The level of correlation is highly significant with post bronchodilator FEV1 and FVC though the correlation is of low strength in cases of PEFR particularly in patients have obstructive disease. On the basis of table 6 it can be concluded that breath holding time greater than 20 seconds corresponds to the FEV1 of 0.64 liters, irrespective of the spirometric abnormality. Hence it can be deduced that patients having a breath holding time greater than 20 seconds, should be allowed to undergo operative procedures.

CONCLUSION

In resource limited condition, Breath holding test can be taken as a non-machine, non-technician dependent, bed side, surrogate test for lung function test. A person having a breath holding test greater than 20 second should be allowed to undergo necessary operative procedures.

LIMITATION OF THE STUDY

- The study was conducted on population consisting of Indian subcontinent and hence a more vast study population comprising all ethnicity and races would help in getting a better correlation equation
- There is no standardization of counting done by patients while performing the single breath count test.

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