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A STUDY OF THE USE OF FORCED OSCILLATION TECHNIQUE IN THE EVALUATION OF COPD PATIENTS: ANALYSIS OF DIFFERENT PARAMETERS AND UTILITY COMPARED WITH SPIROMETRY

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ABSTRACT

Background : The ability to objectively measure lung function in COPD patients is critical in the assessment and treatment of COPD. We thus determined the effectiveness of Forced Oscillation Technique (FOT) as a non-invasive technique to assess lung function in COPD patients and in comparison to spirometry for sensitivity and specificity, testing variability, and the order effect of sequential testing of FOT and spirometry.

Methods : Forty COPD patients (mild, moderate, severe) from PFT Lab of Chest Medicine Department of KEM Hospital, Mumbai and 40 normal healthy individuals (volunteered controls) from various departments of Seth G. S. Medical College, Parel, Mumbai were evaluated in a clinic and under medical care for disease, were asked to perform FOT and spirometry. The utility of FOT and spirometry in differentiating patients that had COPD versus those adults who did not was then analyzed.

Results : The mean age of COPD and control group was 54.1 ± 14.54 years and 53.38 ± 13.25 years respectively. Each group was comprised of 40 patients. Average age of both groups was comparable. (p=0.8163)

Mean FEV1 (%) of COPD and Control group was 55.29 ± 19.42 and 92.11 ± 11.17 respectively. There was significant difference of mean FEV1 values between both the study groups. (p=<0.0001)

Mean FEV1/FVC of COPD and Control group was 58.00 ± 9.86 and 81.81 ± 4.20 respectively. Average FEV1/FVC was significantly higher in control group than COPD. (p=<0.0001

Mean FOT of COPD and Control group was 199.93 ± 75.01and 70.75 ± 44.41respectively. Average FOT was significantly higher in COPD than control group. (p=<0.0001)

Since the AUC value is 0.97, the test has an excellent diagnostic use. The p value is 0.000 (<0.05), so the result is significant. The diagnostic method is intended for use as a diagnostic tool and not as a screening technique. Therefore higher specificity was desired as compared to sensitivity. By analyzing all the values of coordinates, the cut off value of FOT of 126.5 gives sensitivity of 90.0 % and specificity of 97.5%.

Conclusion : In the diagnosis and management of adults with COPD, FOT is a non-invasive approach that easily and objectively measures lung impedance and should be considered as both an adjunct, and in some situations, an alternative to standard spirometry.

KEYWORDS : lung function test, Spirometry, Forced oscillation technique

Introduction

The Forced Oscillation Technique (FOT) is a lung function modality based on the application of an external oscillatory signal in order to determine the mechanical response of the respiratory system. The method is in principal non invasive and requires minimal patient cooperation, which makes it suitable for use in young paediatric patients and old patients. It was first introduced in 1956 by DuBois et al(1). It offers a simple, detailed approach for investigating the mechanical properties of the respiratory system(2).

FOT involves the forced oscillations which are superimposed on the normal breathing. Where, sinusoidal excitations are superimposed on the subject's spontaneous breathing at the airway opening by a loudspeaker(1). This produces oscillations in air flow and thus pressure is recorded and used to estimate the mechanical impedance of the respiratory system(3). This helps in avoiding the need for any special breathing manoeuvre or any interference with respiration. This method is a versatile method and also requires less cooperation of patients(4). From the studies FOT has proved to be as sensitive as Spirometry in detection of airflow impairment and it also requires patient's less co operation, thus can be used for assessment of COPD(5,6).

Among all the diagnostic methods Spirometry is considered as a single most useful test to detect generalized airway obstruction but it requires proper efforts from patients to get proper results. It is relatively non-specific as it gives generalized obstruction idea rather than small airway obstruction. The Forced oscillatory technique involves relatively less efforts and it is also possible to detect the site of airway obstruction with FOT. Patient's Cooperation is the important parameter involved in getting proper results which is possible by FOT. Thus following study was carried out to compare FOT diagnostic tool with Spirometry in COPD patients and normal healthy individuals.

MATERIALS & METHODS

It is anobservational study The study was carried out for 2 years.The study included 40 COPD patients (mild, moderate, severe) from PFT Lab of Chest Medicine Department of KEM Hospital, Mumbai and 40 normal healthy individuals (volunteered controls) from various departments of Seth G. S. Medical College, Parel, Mumbai. 30 to 80 years age group was selected as e.g. 31-35 years, 36-40 years and so on. For 5 COPD patients in one age group, and 1 control in that age group the study was compared for 1 control with 5 COPD patients of same age group and of same sex. The sample size (7) was calculated with the help of formula, derived with the help of software n Master 1.0.

Inclusion Criteria For COPD patients, both sexes between the age between 30 to 80 yearsand have beendiagnosed of COPD according to the GOLD criteria and with previous spirometric results.

Exclusion criteria COPD exacerbation occurring less than 90 days previously.

The presence of secondary infections like tuberculosis, pneumonia, etc.

The presence of thoracic trauma or surgery, respiratory infections occurring less than 30 days previously. COPD patients who have taken bronchodilators during last 12 hours and also inability to perform examinations.

Spirometry : It was performed using standard protocol on the instrument**.**

Forced Oscillatory Technique: There was ROS window on the screen.

Because the ROS resistance is very sensitive to the superior airway resistance, we advised patients to be careful to the head position. We also advised patients, during the measurement, for a calm breathing at rest ventilator level.

Patients were connected to pneumotachograph mouth piece and start icon was clicked to start the visualization of signal. When the curves

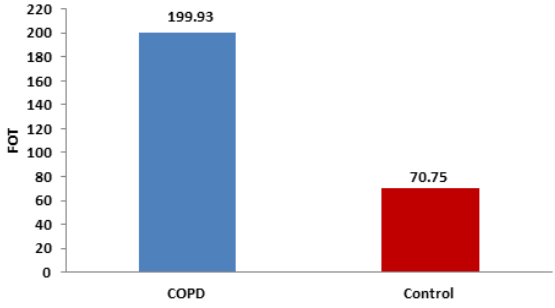
were stabilized, capture icon was selected. The acquisition of the signals for the calculation was started. The acquisition was automatically stopped at the end of the screen.

Acquisition Curve represents the resistance and the phase curves in concordance with time. Numerical acquisition values displays the measured resistances and phases values for each capture.Same procedure was done for controls also. If patient or control who were too weak to perform tests, then procedure was discontinued.

Results

Forced Oscillatory Technique (FOT)

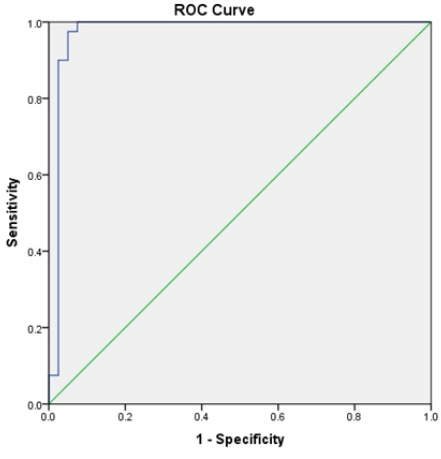
Table 7: Mean FOT		
Characteristics	**COPD**	**Control**
FOT	199.93 ± 75.01	70.75 ± 44.41
P=<0.0001 using unpaired t test		



Graph 6: Forced Oscillatory Technique

Mean FOT of COPD and Control group was 199.93 ± 75.01 and 70.75 ± 44.41 respectively. Average FOT was significantly higher in COPD than control group. (p=<0.0001)

9. The sensitivity and specificity of FOT technique for diagnosis of COPD



Graph 9: The ROC plot of FOT, The red colored circle points towards the nearest value which can be useful as a cut off for diagnosis of COPD.

Table 10: Area Under the Curve (AUC)				
Test Result Variable(s): FOT				
Area	**Std. Errora**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	Upper Bound
.974	.023	.000	.929	1.000
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Since the AUC value is 0.97, the test has an excellent diagnostic use. The p value is 0.000 (<0.05), so the result is significant. The diagnostic method is intended for use as a diagnostic tool and not as a screening technique. Therefore higher specificity was desired as compared to sensitivity. By analyzing all the values of coordinates, the cut off value of FOT of 126.5 gives sensitivity of 90.0 % and specificity of 97.5%.

12. Correlation between decrease in FEV1% measured by Spirometry and airway resistance measured by the FOT.

Table 13: Correlation between decrease in FEV1% and airway resistance		
Characteristic	**Airway resistance by FOT**	**P Value**
Decrease in FEV1%	0.2233	0.1540
Using Pearson's correlation coefficient		

There is no correlation found between decrease in FEV1% and airway resistance. (p= 0.1540)

DISCUSSION

Pulmonary function tests are valuable investigations in the management of patients with suspected or previously diagnosed respiratory disease. They are useful in diagnosis, help monitor response to treatment and can guide decisions regarding further treatment and intervention (8). In this study we included subjects with age of 31-80 years, male preponderance was observed in gender distribution. FEV1% and FEV/FVC was found higher in healthy subjects. FOT value was more in COPD patients. MIP and MEP was significantly higher in control group. The diagnostic method is intended for use as a diagnostic tool and not as a screening technique. Therefore higher specificity was desired as compared to sensitivity. The specificity of FOT, MIP and MEP was 97.5%, 82.5% and 92.5% respectively. FOT showed good reproducibility. The results of these tests revealed that FOT is novel modality to assess pulmonary function with better specificity.

In this study, patients in both groups were in the range of 31-80 years. There was no significant difference of proportion of patients in different age groups between both the study groups. (p=0.7892) The mean age of COPD and control group was 54.1 ± 14.54 years and 53.38 ± 13.25 years respectively. Each group was comprised of 40 patients. Average age of both groups was comparable. (p=0.8163) The 52.5% of male and 47.5% of female were included in COPD group. Control group was comprised of 57.5% and 42.5% of male and female respectively. There was no significant difference of proportion of patients with gender distribution between both the study groups. (p=0.8222) Mean FEV1 (%) of COPD and Control group was 55.29 ± 19.42 and 92.11 ± 11.17 respectively. There was significant difference of mean FEV1 values between both the study groups. (p=<0.0001) Mean FEV1/FVC of COPD and Control group was 58.00 ± 9.86 and 81.81 ± 4.20 respectively. Average FEV1/FVC was significantly higher in control group than COPD. (p=<0.0001)

Nikkhah M et al performed study in healthy and COPD patients. Mean age of control group was 37.6 ± 17.8 years whereas average age of COPD patients was 64.1 ± 15.8 years respectively. Average of study population was 45±19 yrs. FEV1 (Lit) of control and COPD group was 3.2 ± 0.9 and 1.4 ± 0.6 respectively. FEV1/FVC (%) was 88.2 ± 5.3 and 63.6 ± 9.3 respectively. Our findings are relevant to prior data (9).

Di Mango AM et al assessed changes in respiratory mechanics in COPD patients by Spirometry and FOT. FEV (L) of control group was 2.4±0.8 whereas it decreases with severity such as mild (2.3±0.9), moderate (1.5±0.5) and severe (0.8±0.3). FEV1 (%) of control, mild, moderate and severe was 97.9±21.9, 92.7±20.3, 58.7±17.7 and 32.5±12.4 respectively. FEV1/FVC (%) of control, mild, moderate and severe was 82.4±6.6, 70.5±4.0, 55.3±4.5 and 36.0±8.2 respectively (3). Our findings are relevant to prior data.

Mean FOT of COPD and Control group was 199.93 ± 75.01 and 70.75 ± 44.41 respectively. Average FOT was significantly higher in COPD than control group. (p=<0.0001) Mean MIP of COPD and Control group was 39.15 ± 16.49 and 62.07 ± 15.25 respectively. Average MIP was significantly higher in control group than COPD. (p=<0.0001)Mean MEP of COPD and Control group was 34.55 ± 14.24 and 60.85 ± 12.35 respectively. Average MEP was significantly higher in control group than COPD. (p=<0.0001)

Forty known COPD male patients were enrolled in the study performed by Khalil M with mean age 56.8± 7.7 years. Spirometry was done for all patients with mean FEV1 39.5± 15.1%, mean FVC 59.5 ±19.2%, mean FEV1/FVC 52.9± 10.3%. Maximum inspiratory & expiratory pressures were determined with mean 43.6± 26.9% and 46.8± 26% respectively (10).

In our study, ROC curve revealed that the cut off value of FOT of 126.5 gives sensitivity of 90.0 % and specificity of 97.5%. The cut off value of MIP of 56 gives sensitivity of 75.0 % and specificity of 82.5%. The cut off value of MEP of 60.5 gives sensitivity of 55 % and specificity of 92.5%. Moreover, there was no correlation found between decrease n FEV1% by spirometry and airway resistance by FOT. (p= 0.1540) Reproducibility of FOT was assessed by measuring it at 3 times. 1st, 2nd and 3rd reading showed FOT values 199.92 ± 75.01, 200.7 ± 74.89 and 200.8 ± 74.84 respectively. There is no difference in all readings and the test has a good reproducibility. (p=0.6231)

Pang C-S et al performed meta-analysis to assess diagnostic value of oscillation technique for COPD. The meta-analysis suggests a potential role for oscillation technique in diagnosis of COPD, especially FOT, given its easy-to-perform and subject-independent nature. The specificity (95% CI) of FOT was 0.94 (0.86-0.98) in COPD patients (11).

The results of this study revealed that FOT is novel modality to assess pulmonary function in patients with COPD. FOT showed significantly more sensitivity than spirometry. As this is novel of its kind of study in Indian population, there is scantiness of similar studies. More studies are required with larger population to confirm our findings.

CONCLUSION

In summary, we found significant higher specificity associated with FOT than spirometry with consistent reproducibility. FOT showed 97.5% specificity whereas specificity of MIP and MEP was 82.5% and 92.5% respectively. Average FOT of COPD and Control group was 199.93 ± 75.01 and 70.75 ± 44.41 respectively whereas mean FEV1 (%) of COPD and Control group was 55.29 ± 19.42 and 92.11 ± 11.17 respectively. The results of this study revealed that FOT is useful tool for detecting pulmonary function in obstructive conditions.

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