Usefulness Of Inspiratory Capacity Measurement In COPD Patients In Telangana Region

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Objective: To determine if inspiratory capacity (IC) assessment could be useful for chronic obstructive pulmonary disease (COPD) patient management in the primary care setting.
Methods: A descriptive cross-sectional study was conducted in 93 patients diagnosed with COPD. Patients were recruited in eight primary care centers in Telangana region. Anthropometric, socio demographic, resting lung function (forced expiratory volume in one second [FEV1], forced vital capacity, synchronized vital capacity, IC), and quality of life data based on the Saint George's Respiratory Questionnaire (SGRQ) were obtained.
Results: Lung function results expressed as percentages of the predicted values were as follows: FEV1, 49.05 (standard deviation [SD]: 16.24); IC, 61.74 (SD: 15.43). The SGRQ mean total score was 47.6 (SD 17.99). The Spearman's Rho correlation between FEV1 and SGRQ was r □□□0.37 (96% confidence interval [CI]: □0.530 to □0.167), between IC and SGRQ was r □□□0.330 (96% CI □0.503 to □0.132), and between FEV1 and IC was r □□0.562.
Conclusions: Measurement of IC at rest could be used as a complementary functional exploration to forced spirometry in the monitorization of patients with COPD in the primary care setting. We found a poor correlation between IC and quality of life at the same level as in FEV1.

Keywords: inspiratory capacity, primary care, quality of life, COPD

Introduction

Lung volumes and lung capacities referred to the volume of air in lungs at different phases of the respiratory cycle, The average total lung capacity of an adult male is 6 litres of air. Chronic obstructive pulmonary disease (COPD) is a chronic disease characterized by the loss of lung elasticity and airway narrowing resulting in airflow limitation.1,2 This progressive airflow limitation leads to chronic air trapping and hyperinflation, especially during activity or exercise. Hyperinflation causes mechanical disadvantages since it depresses the diaphragm and impairs intercostal muscle contractility. This impairment increases the work and metabolic expenditure associated with breathing and contributes to breathlessness.3 In the diagnosis of COPD, spirometry has been used as an objective measure to confirm its symptom-based clinical suspicion. The diagnostic criteria for COPD include a forced expiratory volume in one second/forced vital capacity ratio (FEV1/FVC) less than 71% of predicted value.1,2 FEV1 in patients with COPD is used to grade the severity of airway obstruction4 and as the main predictor of both disease progression and mortality. However, FEV1 has limited application in clinically assessing patients. For example, patients with mild disease (FEV1 higher than 82% of predicted value) or even patients with severe or very severe disease (FEV1 □ 61% of predicted value) show a poor correlation between their degree of bronchial obstruction and their clinical situation. In these cases patients' quality of life (QoL) and survival can be conditioned by other factors.3 Regardless of the clinical usefulness of spirometry, clinical experience demonstrates that patients sharing very similar FEV1 values could show different blood gas values, clinical parameters, degrees of dyspnea, and very marked differences in QoL. These observations support the existence of other variables which may

intervene in the pathogenesis or evolution of COPD. It is therefore necessary to consider other tests than FEV1 to asses the evolution of COPD patients. In these patients, other parameters such as inspiratory capacity (IC) may be more effective in detecting response to treatment, since they depend less on the degree of obstruction and mechanical compression associated with forced expiratory maneuvers.5 Previous studies have demonstrated the correlation between IC and the patient-centered outcomes of exercise tolerance and dyspnea.6 The aim of this study was to assess the usefulness of IC measurement in the clinical evaluation of COPD patients in the primary care setting. We looked for the relationship between the IC and FEV1 at rest and QoL in these patients.

Methods

This was a cross-sectional, observational study. Simple random patient sampling was carried out in COPD patients,
following a table of random numbers, an initial list was selected after a search with keywords (COPD, chroni bronchitis, or chronic airflow obstruction) included in the informatic application TASS (National Health System application), and among those included in the integrated care process for COPD (COPD disease management program). Patients had to perform a pre- and post-bronchodilator spirometry at the first visit in order to confirm their COPD diagnosis.2 The protocol was approved by ethic committee at the Maheshwara Medical College and Hospital and all patients provided written informed consent. Patients were required to be older than 41 years and to have a spirometric diagnosis of COPD. Exclusion criteria were: inability to perform the tests;2,7 previous history of asthma or comorbidities (neoplasm, other pulmonary and oropharyngeal obstructive disorders, tracheotomized patients, restrictive lung diseases, cardiac failure), and a history of exacerbation that required health care1,4,8 within the 30 days prior to inclusion in the study. The study population was recruited from eight primary care centers in Telangana region. The inclusion period was six months. After estimating a Pearson correlation coefficient of 0.29 for quantitative variables (coinciding with the value determined in similar studies in the primary care setting for FEV1),9 *P* □□0.06, and a power of 0.81 for a bilateral hypothesis, the sample size was found to be 92 individuals (EPIDAT 3.1 software). Sampling was applied to patients presenting criteria compatible with COPD and included in the TASS database and in the COPD integrated care program.

Study variables

Information was collected regarding anthropometric (weight, height) and sociodemographic (age, sex) parameters, smoking habit, QoL, severity (as def ined by SEPAR guidelines, patients with FEV1 expressed as percentage compared to reference: mild FEV1 - 80%; moderate FEV1 60%–80%; severe FEV1 40%–60%; very severe FEV1 - 40%2), specific treatment by therapeutic group in the preceding three months (short- and long-acting anticholinergics, short- and long-acting beta-adrenergics, inhaled/oral corticosteroids, and methylxanthines), oxygen therapy, adjustment of pharmacological treatment to disease severity,2 and frequency of clinical exacerbations requiring attention in a primary care center, emergency room, or hospital admission.

Data were likewise collected on lung function as defined by FEV1 and IC. Testing met SEPAR recommendations. Reproducibility criteria was defined. Spirometry was derived from flow-volume loops. After a period of tidal breathing, subjects were instructed to inhale to total lung capacity and then exhale as quickly and forcefully as possible to residual volume and then inhale back to tidal volume. Exhalation was continued until lungs were emptied completely with absence of further flow. FEV1 was derived from these loops. To measure IC, subjects completed four tidal breaths, inhaled to total lung capacity, and then exhaled slowly to residual volume. Exhalation was continued until lungs were emptied completely with absence of further flow. IC was calculated through the formula: IC □□synchronized vital capacity (SVC) – expiratory reserve volume (ERV).

Reference values used for the different expiratory variables were those obtained for the Telangana population.10,11

Measurement instruments

Patients performed lung function testing with their usual pharmacological treatment. A Lilly-type Datospir 120D pneumotachometer spirometer was used. To assess the COPD patients' QoL, the St. George's Respiratory Questionnaire (SGRQ), was used.12–14 This questionnaire included 50 items across three domains: symptoms, activity, and impact. The items corresponding to the symptoms domain refer to the frequency and severity of the respiratory symptoms. The activity domain addresses activity limitation due to breathlessness. The impact domain evaluates social functioning and psychological disturbances resulting from airways disease. The questionnaire items are presented in two ways: questions with up to five possible answers (only one can be chosen), or dichotomous-reply (yes/no) questions. The scores range from 0 to 100, with lower scores indicating improvement and a deviation of four units or more were considered to be clinically meaningful.

Data collection

After being informed about the characteristics of the study and the confidentiality of the data, and once written consent was obtained, patients were scheduled for a visit in their corresponding primary care centers to assess their chronic airflow obstruction by spirometry. They were then instructed not to discontinue their usual pharmacological treatment. In the scheduled visit, sociodemographic, anthropometric, and smoking data were collected. Patients were asked about their specific pharmacological treatment (if any). Both active drugs and daily doses were recorded. This was followed by self-administration of the SGRQ and posterior lung function test performance. Forced spirometry comprised the record of three correct maneuvers according to the standards for lung function test performance. Patients were finally instructed to performance a complete exhalation until SVC was obtained three times. Data was collected through a paper case report form (CRF) specifically designed for this study. All data were introduced in a Microsoft Access database (Microsoft, Redmond, WA, USA) and processed with the SPSS statistical package (v. 12.0; SPSS Inc., Chicago, IL, USA).

Statistical analysis

Frequency tables for categorical variables were completed for our descriptive statistical study, and the mean, standard deviation (SD), and median for continuous variables were calculated. Calculation of the linear correlation coefficient between quantitative variables was based on the Spearman's Rho statistic for nonparametric tests. Confidence intervals were calculated for the correlation coefficient, using the Fisher transformation. The level of significance was established at 95%.

Results

The results obtained from the random selection of patients (Figure 1) reveal inadequate quality of the diagnostic registries in the primary care clinical histories with mistakes in diagnosis in up to 30% of the patients. Because of the variability in the diagnoses registered in the medical history it was necessary to search the patient records with keywords that would allow greater sensitivity in the identification of eligible patients. The simple random sampling before the inclusion guarantees the same representation of all COPD patients according to disease severity. In the scheduled visit, the investigators confirmed that patients met the diagnostic criteria of COPD. Patients with recent exacerbations were excluded in order not to affect the results. From a random selection of individuals, 93 patients were included from the population with COPD registered in the electronic case history database (Figure 1).

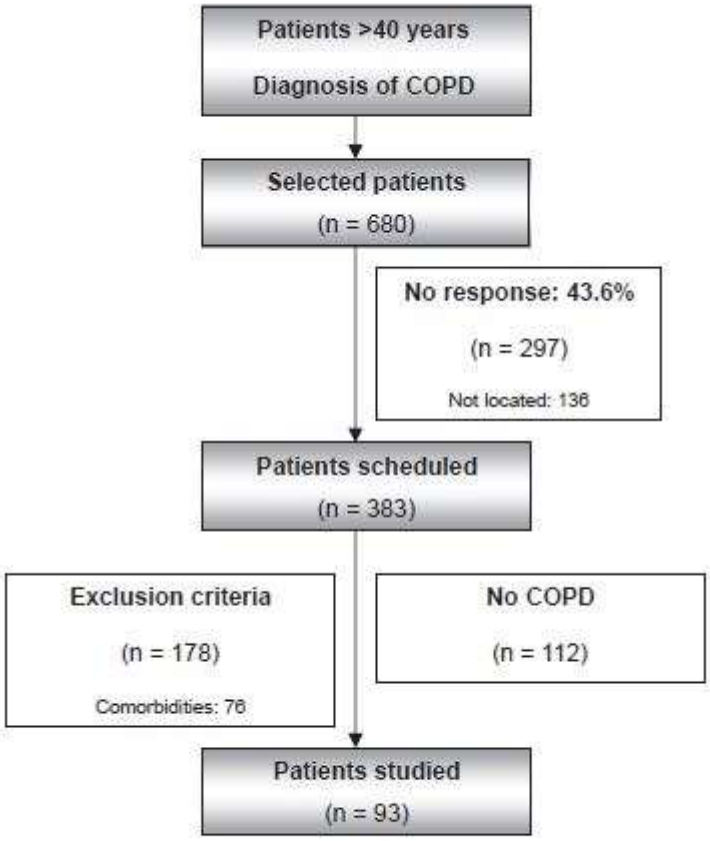

Figure 1 Study population. Total numbers with inclusion and exclusion criteria and nonresponse.
Abbreviation: COPD, chronic obstructive pulmonary disease.

The mean age of the 93 participants was 68.5 years (SD 7.9), 96.7% were male and 35.6% were current smokers.
Their COPD severity stage had the following distribution: mild, 5.5%; moderate, 39.7%; severe, 39.7%; and very severe, 16%. Pharmacological treatment followed guidelines1,2 in 59.2% of cases. The characteristics of the study population showed most patients were male with conditions amenable to improvement such as smoking at the time of the study and treatment optimization according to disease severity. Table 1 reports the bivariant analysis of lung function parameters (FEV1, FEV1/FVC, IC, forced expiratory flow [FEF] 25%–50%) and QoL, according to severity, gender, and therapeutic optimization. The mean total SGRQ score was 47.5 (SD 17.98). Table 2 shows the correlations between FEV1 and IC and total SGRQ score for each degree of severity. The correlation coefficient between FEV1 and SGRQ was □0.36 (95% CI: □0.17 to □0.53), and the correlation coefficient between IC and SGRQ was □0.33 (95% CI: □0.13 to □0.50). Figure 2 presents the dispersion graphics and linear correlation values between IC and FEV1. The statistical correlation between FEV1 and IC was r □□0.516.

Discussion
Misdiagnosis between COPD and other respiratory diseases such as asthma could cause inadequate management of these diseases. There are a large number of patients who enter primary care practices with a prior respiratory diagnosis, or who have received respiratory medications without a clearly established diagnosis.15 Data from COPD patients in previous epidemiological studies in Telangana region has shown a high COPD prevalence (9.1% in general population aged > 40 years) and high rates of underdiagnosis16 (78.5%). The data demonstrates that most of these patients were

incorrectly treated according to COPD guidelines.16 In this study, thepercentage of misdiagnosis in our population was high: 29.3% of COPD patients did not meet COPD spirometric diagnostic criteria. In order to efficiently identify which patients need further evaluation with spirometry, the general practitioner needs help to identify those patients who are most likely to have a fixed obstruction.15 Spirometry should be performed in all patients suspected of COPD to diagnose the disease and to assess disease severity. The spirometric definition of COPD includes the presence of a post bronchodilator FEV1/FVC-70% in order to confirm the presence of airflow limitation that is not fully reversible.17 Although these variables can be measured accurately and precisely in clinical research, they may be inconsistent in a primary care setting. This inconsistency may be related, at least in part, to incorrect interpretation of the spirometry results (only 47% of primary care physicians correctly interpreted spirometry results).18 As we have mentioned before, FEV1 has a poor correlation with clinical definition of COPD.3 In order to increase the correct diagnosis of patients with COPD, a possible alternative to FEV1 could be another parameter such as dyspnea, QoL, or IC. These parameters have established correlations with exercise tolerance and physical activity. In COPD, hyperinflation or air trapping is the result of airway obstruction and the destruction of the lung parenchyma and its vasculature. In recent years, the dynamic hyperinflation in these patients has been recognized as a factor that triggers dyspnea and reduces exercise capacity. The degree of dynamic hyperinflation can be assessed by measuring reduction in IC. The measurement of IC in primary care settings is very rarely performed and no references were found in this setting to date.

Table 2 Determination of linear correlation coefficients of IC and FEV1 with the St. George's Respiratory Questionnaire and disease severity

Variables	FEV_1		IC	
	Rho spearman (IC95%)	P	Rho spearman (IC95%)	P
St. George's Respiratory Questionnaire				
Total score (n = 90)	−0.36 (−0.53 a −0.17)	<0.001*	−0.33 (−0.50 a −0.13)	0.002*
Impact domain (n = 92)	−0.28 (−0.46 a −0.08)	0.007*	−0.31 (−0.48 a −0.11)	0.003*
Symptoms domain (n = 92)	−0.15 (−0.34 a 0.06)	0.16	−0.15 (−0.35 a 0.05)	0.142
Activity domain (n = 92)	−0.42 (−0.57 a −0.23)	<0.001*	−0.32 (−0.49 a −0.12)	0.002*
Severity				
Mild (n = 5)	0.05 (−0.87 a −0.89)	0.94	0.80 (−0.28 a 0.99)	0.10
Moderate (n = 37)	−0.16 (−0.46 a 0.17)	0.34	−0.30 (−0.567 a 0.03)	0.08
Severe (n = 37)	−0.38 (−0.38 a −0.06)	0.022*	−0.40 (−0.642 a −0.09)	0.015*
Very severe (n = 14)	0.07 (−0.47 a 0.58)	0.81	0.33 (−0.243 a 0.73)	0.27

Note: *statistically significant.
Abbreviations: CI, confidence interval; IC, inspiratory capacity; FEV_1, forced expiratory volume in one second.

Table 1 Bivariate analysis of the pulmonary function results and characteristics of the patients

Variables	IC	FEV_1	FVC	FEV_1/FVC	FEF 25%–50%
	Mean % (SD) P	Mean % (SD) P	Mean % (SD) P	Mean % (SD) P	Mean % (SD) P
Sex	0.896	0.161	0.492	0.148	0.153
Male	62.88 (4.59)	62.00 (12.29)	69.33 (10.02)	86.67 (9.86)	40.33 (10.69)
Female	61.69 (15.66)	48.61 (16.22)	63.47 (14.56)	71.34 (18.02)	28.49 (14.04)
Severity	<0.001	<0.001	<0.001	<0.001	<0.001
Mild	71.37 (16.09)	82.60 (2.79)	90.00 (8.09)	87.40 (12.48)	58.80 (5.02)
Moderate	70.18 (13.71)	61.67 (6.32)	72.38 (9.11)	80.25 (15.20)	38.50 (8.77)
Severe	55.09 (11.35)	40.46 (5.69)	57.57 (9.76)	68.03 (16.19)	21.03 (6.75)
Very severe	53.51 (16.96)	26.36 (3.41)	47.28 (9.07)	54.71 (14.95)	14.21 (5.92)

Note: Mean %, mean percentage of theoretical value.
Abbreviations: IC, inspiratory capacity; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; FEF 25%–50%, forced expiratory flow 25%–50%; SD, standard deviation.

Hyperinflation in early COPD is not typically discerned by radiography but must be assessed objectively through lung volume testing (ie, body plethysmography).19 Hyperinflation is discerned only in advanced COPD by radiography that shows an expanded chest, increased retrosternal air space, low and flat diaphragms, and decreased peripheral vascularity. Increased airway resistance, decreased lung elastic recoil and tethering properties, and premature airway closure results in an increased functional residual capacity (FRC).20

All COPD patients at rest show a variable degree of pulmonary hyperinflation, but IC reduction may have noconsequences for gas exchange or may cause dyspnea. During exercise in COPD patients, the tidal volume doesn'tincrease properly because of reduced IC and results in incomplete emptying of the lungs during the expiration (air trapping).

This becomes even more important when the intensity of physical exercise increases (and thus ventilation) giving rise to dynamic hyperinflation21 and worsening of air trapping, dyspnea, and exercise tolerance.22 The dynamic hyperinflation explains the limited exercise tolerance and breathing difficulties observed during daily life activities in COPD patients.23 The administration of bronchodilators in some cases may not improve FEV1 but they might improve air trapping and consequential dyspnea and exercise tolerance.24,25

The results of the present study reveal the normal statistical distribution of IC values with dispersion of the values that allows correlations to be established with subjective measures of QoL perception. In our study, we observed a correlation between IC and SGRQ (□0.33; 95% CI: □0.13 to □0.50) showing that IC does affect the QoL of COPD patients. Similar correlation coefficients were observed between FEV1 and QoL and between IC and QoL as measured at rest by the SGRQ.

Measurement of IC at rest may complement forced spirometry in the monitoring of patients with COPD in the primary care settings. In contrast to parameters such as age, body mass index (BMI) or FEV1, a statistically significant and clinically relevant correlation is observed between the change in IC and dyspnea after exercise test (six-minute walk test).21 These observations suggest that the measurement of IC may constitute an objective indicator of dynamic hyperinflation and air trapping in COPD.

It seems reasonable to consider the usefulness of IC, with equivalence to FEV1 in its correlation to QoL perception, and with higher correlation to FEV1 in terms of dyspnea after exercise testing.26 However, there is insufficient evidence on the reliability, reproducibility, and interindividual variability of IC. Moreover, and unlike that in FEV1, the cut-off points or percentiles allowing classification of severity of the obstructive lung disease, its evolution over time, and the severity of air trapping or hyperinflation as a function of IC remain to be defined.

While the results of the statistical correlation between FEV1 and IC for the population studied allow us to postulate our working hypotheses, further studies are required taking into account prognostic variables relating to COPD morbidity–mortality, in order to define the measurement of IC as a complement to FEV1, or even as an alternative to forced spirometry in those cases where such exploration is difficult or not possible in the primary care setting.

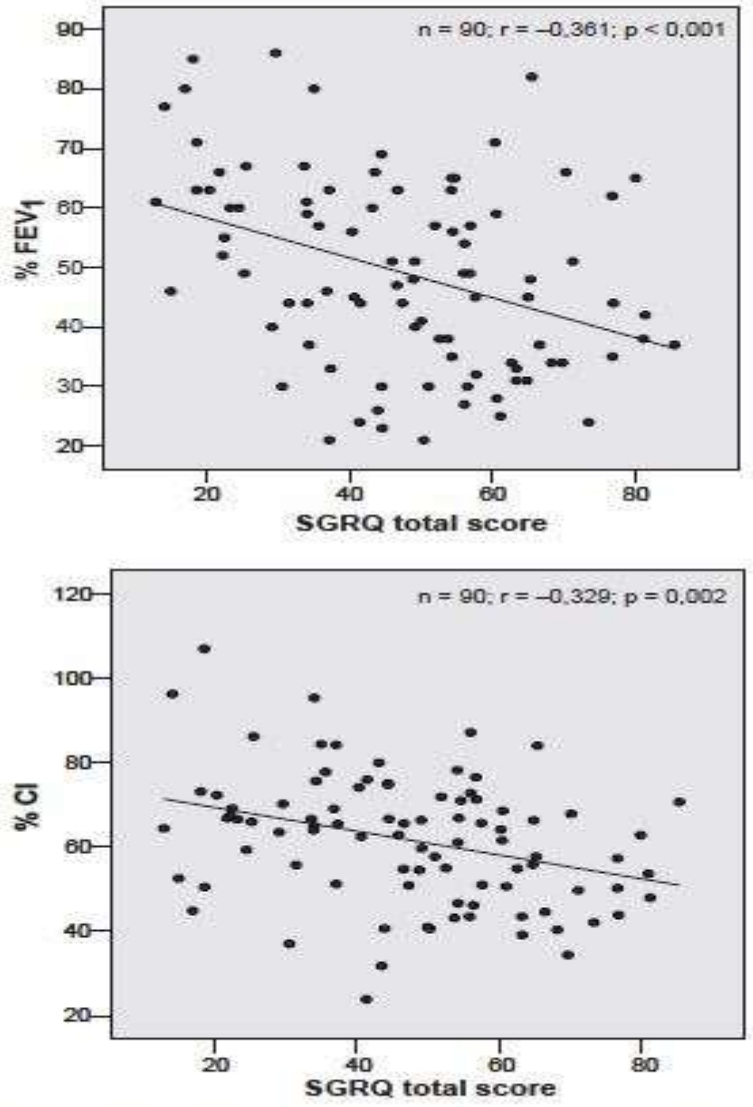

Figure 2 Dispersion and linear correlation values for the correlation between FEV_1, IC, and the St. George's Respiratory Questionnaire score.
Abbreviations: IC, inspiratory capacity; FEV_1, forced expiratory volume in one second.

We observed a relationship between the correlations of FEV1 and IC with the QoL reported by COPD patients. Taking in mind this correlation, we believe that the measurement of IC in primary care may be a useful complement to forced spirometry in the monitoring of COPD, particularly when forced spirometry is difficult or impossible to perform.

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