

Is there a discrepancy between a physical law and the spirometric definition of airflow obstruction?

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Abstract

Background: It has long been emphasized that if physicians rely on clinical signs and symptoms only, they may under-diagnose many of the airflow-limited patients. But what if they rely on spirometry alone and overlook physical examinations as the case is now? Interesting studies on physics of sounds show that wheezing is definitely indicative of an airflow limitation, but, according to current guidelines, presence or absence of wheezes has not been taken into consideration for diagnosis. The purpose of present study was to detect the degree of spirometric deterioration in patients who were physically presumed to have definite airflow obstruction, namely diffuse bilateral wheezes.

Methods: In a cross-sectional study, adult patients complaining of chronic cough and/or dyspnea were visited by two specialists at a pulmonary clinic. If both pulmonologists' agreement about presence of wheezes, the patients would be sent for spirometry. Spirometry maneuvers were performed according to the American Thoracic Society (ATS) standards. First eighty patients who could perform acceptable spirometry were selected. Prevalence of a forced expiratory volume in first second over forced vital capacity (FEV_1/FVC) and/or FEV_1 /slow vital capacity (SVC) below 70% were calculated in these patients with a very high probability of airflow obstruction based on the physical laws.

Results: In our patients' setting with diffuse bilateral wheezes, the means of predicted percentages for FEV_1 , FVC and SVC were $60.3 \pm 7.1\%$, $72.5 \pm 17\%$ and $69.9 \pm 6.2\%$ respectively. The mean of FEV_1/FVC and FEV_1/SVC could be sequenced as $68.38 \pm 10.6\%$ and $68.44 \pm 11.6\%$ percent. In 32 (40%) patients, both values were less than 70%, and 31 (38.8%) had both values of more than 70%. On the other hand, in 11 (13.7%) patients, only FEV_1/FVC and, in 6 (7.5%), only FEV_1/SVC were less than 70%. As the results show, even in our patients' setting, those who met the gold standards for airflow obstruction from the viewpoint of physical laws, spirometric obstruction was present only in 61.2% ($40\% + 13.7\% + 7.5\%$) of the cases.

Conclusion: The results show a discrepancy between wheezing, as a physical symptom of obstruction, and spirometric findings. Spirometry, as a tool for screening asymptomatic persons, has proved to have a good sensitivity, but the results of present study indicate that this may be not the case for wheezy symptomatic patients.

Keywords: Obstructive lung diseases; Physical examination; Respiratory function tests; Respiratory sounds; Spirometry

Abbreviations: ATS: American Thoracic Society; COPD: Chronic Obstructive Pulmonary Diseases; ERS: European Respiratory Society; GOLD: Global Initiative for Chronic Obstructive Lung Disease; LLN: Lower Limit of Normal; NICE: National Institute for Clinical Excellence

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Introduction

Spirometry is a valuable tool in evaluation of patients with airflow obstruction. It is used for diagnosis and staging of chronic obstructive pulmonary disease (COPD), confirmation of asthma and determining the efficacy of asthma treatment [1]. In the medical office setting it is useful for both diagnostic and monitoring purposes [2]. It is also used for screening and surveillance programs in workers with exposures to agents associated with pulmonary diseases [3,4].

Early detection of airflow obstruction is also important for many reasons. Airflow obstruction is a marker of increased risk of death from heart disease, lung cancer, and stroke [5-7]. COPD is a leading cause of both morbidity and mortality [5]. A consensus statement of the European Respiratory Society (ERS) emphasized the importance of spirometry in early diagnosis of COPD in asymptomatic patients [8]. Early detection of airflow obstruction is particularly important for young adults because they are more likely to benefit from intervention [9].

However, the big problem is that the prevalence of airflow obstruction varies widely with the definition used, and there seems to be a need for constant refinement of spirometric standards. In the National Heart, Lung, and Blood Institute (NHLBI) / World Health Organization (WHO), Global Initiative for Chronic Obstructive Lung Disease (GOLD) and National Institute for Clinical Excellence (NICE) guidelines, the $FEV_1/FVC < 70\%$, as a fixed value, is used to detect airflow obstruction [10,11]. The ERS defines COPD as $FEV_1 / (FVC \text{ or } SVC) < 88\%$ of predicted value in men and $< 89\%$ of predicted value in women (i.e. > 1.64 residual standard deviation below the predicted value) [8]. In November 2005, ATS and ERS developed joint guideline for accurate and reproducible diagnosis of airflow obstruction [12,13].

Up to now there are little emphases on clinical signs and symptoms, like diffuse wheezes, for diagnosis of airflow obstruction. Most guidelines use spirometry only; however, at least in 1995, ATS guideline also used a patient reported symptoms and physician diagnoses taken from patient history, but nothing from physical examination [14].

Importance of wheezing became more relevant when we consider interesting studies on the physics of the sound models proposed by Grotberg and David [15] and Grotberg and Reiss [16,17]. They showed with their models that wheezing will always be accompanied by flow limitation, but that flow limitation will not necessarily be accompanied by wheezing.

The purpose of present study was to detect the degree of spirometric deterioration in patients who were physically presumed to have definite airflow obstruction, which means had diffuse wheezes on auscultation.

Material and Methods

This cross-sectional study was performed in winter of 2012 at the hospital of Shahid Sadoughi medical university, Yazd, Iran. This study was approved by the Shahid Sadoughi hospital ethics committee (NO. 29352 / Date: June 1st, 2011). The committee waived the need for written consent, and claim it sufficed to inform all the participants that there is no risk in spirometry as a diagnostic test.

Exclusion criteria consist of factors that can make spirometry results inaccurate and unreliable. These are vertebral column, thoracic cage or abdominal abnormalities (e.g. kyphoscoliosis), neuromuscular diseases, cardiovascular diseases (e.g. heart failure), history of chest trauma or anemia, malignancy and thoracic or abdominal surgery in previous three months.

Pulmonary clinic patients who complained of chronic cough and/or dyspnea of more than six weeks' duration, without prior diagnosis, were participated. Two board-certified pulmonary physicians (first author and a colleague) examined participants for the presence of bilateral wheezes. If there was disagreement between two pulmonologists, even for staging of wheezes, the participant was excluded. Those who were included, send for spirometry.

Spirometry was performed by a Fuduka ST-250 spiroanalyzer (Fukuda Sangio Co, Japan) according to ATS criteria [18,19]. Eighty consecutive acceptable tests from patients older than 15 years were included and analyzed (87 patients tested totally).

We consider both FEV_1/FVC and FEV_1/SVC percent values below 70% as spirometric equivalent of airflow obstruction (recommended in NICE and GOLD guidelines, respectively).

Statistical Analysis

Statistical analysis was done using SPSS software for Windows (Release 22.0, SPSS Inc., Chicago, USA). We used Cohen's κ to determine if there was agreement between two pulmonologists' judgement on whether individuals had wheeze or not. We consider standard deviation for participants' FEV_1/FVC and FEV_1/SVC percent values equal to 10 based on a pilot study. Desired total width of the confidence interval is 6 (or ± 3) for FEV_1/FVC and FEV_1/SVC percent values in COPD, based on spirometry guidelines. Therefore, we need at least 74 participants to achieve 99 percent confidence interval. Two-tailed p-values < 0.05 were considered significant.

Results

We examined spirometry from 80 patients. There are 68 males (85%) and 12 females (15%), with mean age of 44.9 ± 15.7 and 34.4 ± 9.4 years, respectively. **Table 1** shows the mean values of spirometric parameters. **Table 2** shows spirometric data of all patients. As you see in **Table 2**, using FEV_1/FVC or FEV_1/SVC below 70% (as fixed ratios) singly resulted in diagnosis of obstructive pattern only in 53.7% and 47.5% respectively; while, applying both spirometric criteria, could label 61.2% of participants as having an obstructive pattern on spirometry.

The two pulmonologists agreed on 87 patients whom had wheeze and 35 patients whom didn't have wheeze. However, first pulmonologist confirmed seven patients had wheeze when second pulmonologist confirmed they did not. Conversely, first pulmonologist confirmed ten patients did not have wheeze when second pulmonologist confirmed they had wheeze. Cohen's κ test revealed there was a good agreement between the two pulmonologists judgements, $\kappa = .716$ (95% CI, .591 to .841), $p < .0005$.

Table 1: Mean values of spirometric parameters.

Spirometric parameters	Mean \pm SD*
FEV ₁ predicted %	60.3 \pm 7.1
FVC predicted %	72.5 \pm 17
SVC predicted %	69.9 \pm 6.2
FEV ₁ /FVC	68.38 \pm 10.6
FEV ₁ /SVC	68.44 \pm 11.6

Table 2: Spirometry data in patients.

Number of the patients (percentage)	FEV ₁ /FVC < 70%	FEV ₁ /FVC > 70%
FEV ₁ /SVC < 70 %	32 (40%)	6 (7.5%)
FEV ₁ /SVC > 70 %	11 (13.7%)	31 (38.8%)

Discussion

The present survey may aim to examine the relations between spirometric and physical signs of airflow obstruction. Patients with chronic cough and/or dyspnea plus bilateral diffuse wheezes on auscultation were presumed very suspicion to have airflow obstruction clinically and physically (based on physical law, which consider wheezing as the definite indicator of airflow limitation). However, even in this clinical setting with very high probability for airflow obstruction, applying both spirometric criteria of FEV₁/FVC and FEV₁/SVC below 70% (as fixed ratios), could label only 61.2% of patients as having an obstructive pattern on spirometry. These results are indicative of substantial discrepancy, which if correct, means large under-diagnosis by using simple spirometry alone in these situations (even when applying both spirometric criteria to identify more cases (61.2%); rather than using each singly (53.7% and 47.5%).

Our patients had a mean FEV₁ of 60%, which shows a moderate spirometric obstruction. It should be concerned that patients with more severe obstruction will show a better spirometric distinction.

Despite the relevant importance, there is no unique standard reference guideline for accurate distinction of airflow obstruction by spirometry alone. However, use of clinical and spirometric findings concomitantly may help better distinction of airflow limited patients.

The most relevant problem is that the prevalence of airflow obstruction varies widely with the definition used. Anne Lindberg et al. showed the difference in the prevalence of COPD according to spirometric criteria of British Thoracic Society (BTS), ERS, GOLD, and ATS guidelines in a random sample of adults [20]. Although, a majority of patients reported airway symptoms and contact with health care providers due to respiratory complaints, only a minority was diagnosed as COPD patient by spirometry. This can indicate a large under-diagnosis, and show a discrepancy in diagnosis based on patient symptoms and spirometry, same as our results.

Using a fixed FEV₁/FVC < 0.70 as recommended by GOLD and NICE guidelines, [10,11] will lead to a substantial under-diagnosis of airflow obstruction in younger, and over-diagnosis of COPD in older individuals [21]. Therefore, some researchers suggest the

use of lower limit of normal (LLN) instead of a fixed ratio [22,23]. Cerveri et al. reported that only 45.6% of the subjects with airflow obstruction by the LLN were also identified by a fixed cut-off [9].

In ERS guidelines [8] the predicted value of FEV₁/FVC or FEV₁/SVC declines with age and the limit is higher for women (89% of predicted); although, the COPD diagnosis according to the ERS definition will include young females and exclude older men to a greater extent than the NICE and the GOLD definitions [24].

Since the main problem is under-diagnosis of airflow obstruction by spirometry even when the newest guidelines are used, many researchers tried to establish other spirometric criteria for better distinction of airflow obstruction [22,23,25]. Some recommend the use of FEV₆ instead of FVC, but relatively low sensitivity of this criterion may also result in the underestimation of airflow obstruction [26].

Kreider ME and Grippi MA report that uses of the new ATS/ERS interpretation scheme leads to a diagnosis of obstruction in a greater proportion of patients undergoing pulmonary function testing [27].

It seems that no matter what criteria are used; spirometry alone cannot extract a large subgroup of patients with airflow obstruction. Furthermore, there is no place for clinical signs and symptoms alone or in combination with spirometry in most guidelines. In the 1995 ATS guidelines, symptoms and physician diagnosis, both from history are taken into account, but there is no role for physical signs like presence of diffuse wheezes. Results from interesting studies on physics of the sound models by Grotberg and David [15] and Grotberg and Reiss [16,17] showed that wheezing is always an indicative of flow limitation. We suggest that a preclinical air limitation screening symptom, like wheezing, in a patient with difficulty breathing, can prevent the under diagnose of airflow limitation by using spirometry alone.

It is probable that sensitivity of spirometry as an indicator of airflow obstruction in the setting of wheezy patients may be less than for screening of asymptomatic persons.

There are no known prior studies assessing the efficacy of wheezing as a preclinical symptom for clinically diagnosed airflow limitation demonstrated by spirometry. Therefore, the study warrant further study to assess this method of assessment for the diagnosis of the respiratory diseases.

Conclusion

Our results may show a discrepancy on the presence of airflow obstruction between clinical/physical rules and spirometric definition. It is an idea that adding clinical signs and symptoms to spirometric criteria may lead to better distinction of airflow obstruction.

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