

CHAPTER 1

Spirometry to detect and manage chronic obstructive pulmonary disease and asthma in the primary care setting

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Most people with chronic obstructive pulmonary disease (COPD) are unaware of the smoldering airway inflammation present in their lungs, which places them at increased risk for premature morbidity and mortality [1–3]. However, COPD is easily detected in its preclinical phase using office spirometry; and successful smoking cessation prevents further disease progression [4]. In the near future, other interventions may also be proven to reduce the rapid decline in lung function experienced by patients with chronic airflow limitation. When patients complain of intermittent cough, wheezing, chest tightness, and shortness of breath, spirometry carried out when the symptoms remain current can often detect the reversible airflow limitation characteristic of asthma. Spirometry also helps to categorise the severity of asthma and confirms response to therapy [5]. Office spirometry is defined as spirometry performed in the primary care (general practitioner) setting.

Office spirometry measures the forced expiratory volume in one second (FEV₁)/vital capacity (VC) ratio (or surrogates like FEV₁/forced vital capacity (FVC) or FEV₁/forced expiratory volume in six seconds (FEV₆)). This ratio is the most sensitive and specific test for detecting airflow limitation. Spirometry also measures the per cent predicted FEV₁, which is the most widely accepted index of the severity of airway obstruction [6, 7]. General practitioners see the majority of adult smokers and patients with asthma, but fewer than half use an office spirometer regularly [8, 9]. Barriers include the perceptions that spirometers are expensive and difficult to use and maintain, that the test disturbs patients and takes too much time to complete, that the reports are too difficult to interpret, and that spirometry testing does not affect clinical outcomes.

Improvements in office spirometers

Recent improvements in spirometry hardware and software make it less expensive, faster, and easier to obtain good quality spirometry test sessions, with automated interpretations which aid clinical decision-making [10]. Pulmonary specialists and their professional societies can use their knowledge and experience with pulmonary function testing to help general practitioners to select a new office spirometer. Attempts to use older spirometers often lead to frustration and abandonment by primary care practitioners. Volume spirometers are too large, too expensive, risk cross-contamination, and are difficult to maintain in the office setting. Older flow-sensing spirometers may quickly become inaccurate as their sensors become clogged, and many lack quality

assurance software and modern reference equations [11]. Some new office spirometers are as accurate as older volume spirometers [12].

Almost all spirometers that are sold now use an internal microprocessor or are connected to a personal computer. See figure 1 for photographs of office spirometers. The primary function of the computer is to measure the spirometry results for each manoeuvre, calculate predicted values, and format a printed report. Office spirometry software should also help the spirometry technologist to obtain better quality test sessions [13, 14]. Each manoeuvre should be checked for acceptability and appropriate error messages displayed (table 1). As additional manoeuvres are performed, the repeatability of the FEV₁ and FVC are determined, and a quality grade (A–F) computed for the test session. The goal is to obtain an A or B grade by performing additional acceptable FVC manoeuvres. An unbiased professional group will test the features of



Fig. 1. – Photos of several hand-held, battery operated, office spirometers.

Table 1. – Manoeuvre quality checks and test session quality grades

Acceptable manoeuvres:

Fast start (BEV <0.15 L)

Valid FEV₆ (FET >6 s or FET 2–6 s with EOTV <0.04 L)

Test session quality grades

A = at least three acceptable manoeuvres,
with the largest two FEV₁s matching within 0.1 L
and the largest two FEV₆s matching within 0.1 L

B = at least two acceptable manoeuvres,
with FEV₁s matching within 0.15 L

C = at least two acceptable manoeuvres,
with FEV₁s matching within 0.2 L

D = only one acceptable manoeuvre (with no interpretation unless normal)

F = no acceptable manoeuvres (with no interpretation)

BEV: back extrapolated volume; FEV₆: forced expiratory volume in six seconds; FET: forced expiratory time; EOTV: end-of-test volume; FEV₁: forced expiratory volume in one second; There is no E grade specified for test quality (due to an academic tradition).

office spirometers, such as QC software, using a standardised checklist. The results will be posted on the National Lung Health Education Program (NLHEP) website [15, 16] as a guide to "consumers" who are planning the purchase of an office spirometer. A similar service should be provided in Europe. See table 2 for a short list of desirable spirometer features.

Six second manoeuvres

Office spirometry is faster and easier using six second manoeuvres. The six second FVC (FEV₆) is slightly smaller than the FVC (and the slow VC) when healthy persons are tested, so reference equations for the FEV₁/FEV₆ and the FEV₆ must be used [17, 18]. The FEV₆ is more reproducible than the traditional FVC. The FEV₁/FEV₆ is just as good as the traditional FEV₁/FVC for diagnosing airflow limitation and for predicting FEV₁ decline in smokers [19, 20]. Short manoeuvres (without volume–time plateaus) increase the risk of misclassification when traditional reference equations are used. The use of six second manoeuvres reduces technologist and patient fatigue, and also eliminates the risk of syncope when compared to prolonged FVC manoeuvres. However, reference equations for the FEV₆ are not yet widely available from European studies. Until then, the traditional slow, inspiratory, or FVC may be used for the denominator in the equation for the ratio FEV₁/VC.

How to minimise misclassification

Unlike many medical tests during which the patient remains passive, spirometry testing requires cooperation and an almost athletic breathing manoeuvre. With sub-maximal effort, the results are erroneous (false positive or false negative for disease or change in severity). The misclassification rate is about 5% in most research and sub-specialty settings, but the current authors experience is that misclassification has been higher in primary care settings. The most common cause of error is inadequate spirometry training and experience of the person performing the test [10, 11]. Instrument inaccuracy or malfunction is much less frequently at fault.

The sources of variation of within-subject FEV₁ measurements may be divided into technical and biological components. The technical sources of error may be further divided into those introduced by the instrument and those introduced by the interactions between the technician and patient. Improvements in spirometry hardware and manufacturing quality control, prompted by the development of clearly-defined international standards, have reduced technical sources of variation due to the instrumentation over the last decade. Checking volume accuracy using a 3.00 L syringe

Table 2. – Desirable features of new office spirometers

Only FEV ₁ , FVC, and FEV ₁ /FVC are reported
Automated manoeuvre quality checks
Test session quality grades (A–F)
Use of reference equations for six second manoeuvres
Disposable, reliable, inexpensive flow sensors
Flow–volume and volume–time curves are printed
Reports printed on plain paper
Automated interpretations
Rugged, battery power, 3 yr warranty

FEV₁: forced expiratory volume in one second; FVC: forced vital capacity.

filled with room air detects most sources of instrument drift and differences in the accuracy of disposable flow sensors.

The primary source of variability is now the technician–subject interaction. Spirometry tests, unlike electrocardiograms and venipuncture, require effort on the part of the subject, prompted by directions from the technician. Each FVC manoeuvre requires maximal effort during three phases of an "unnatural" breathing manoeuvre: 1) maximal inhalation; 2) maximal exhalation for at least one second (for FEV₁); and then 3) continued exhalation for several seconds (for FVC). Submaximal inhalation effort during the first phase reduces both the FEV₁ and the FVC. A submaximal exhalation blast during the second phase affects the FEV₁; and an incomplete (short) exhalation during the final phase will reduce the measured FVC. Any (and sometimes all) of these three phases of the manoeuvre can go wrong, usually because of suboptimal communication between the technician and the subject, but sometimes because of fatigue, lack of interest, or poor mental function. See figure 2 for examples of poor quality spirometry manoeuvres.

The current European Respiratory Society (ERS) and American Thoracic Society (ATS) goals for spirometry quality (three acceptable manoeuvres, the best two of which are reproducible) [21, 22] are *not* unrealistic, at least in the hospital-based pulmonary function testing (PFT) laboratory and research settings. Ninety-five per cent of 18,000 tests of adult patients, performed by 16 technicians in a very large clinical PFT lab, met ATS standards [23]; and 95% of 4,000 tests of elementary and high school students (aged 9–18 yrs) performed by 12 different technicians in a research study, also met ATS standards [24]. Tests of patients with asthma enrolled in six large multicentre asthma research studies at 232 sites also met ATS goals [25]. Even nine out of 10 tests in elderly people at their first research study visit could meet ATS standards [26].

A recent study in The Netherlands compared the spirometry results carried out by 388 patients with mild-to-severe COPD first tested in four hospital-based PFT laboratories with repeat studies carried out in 61 general practice outpatient clinics [27]. The same

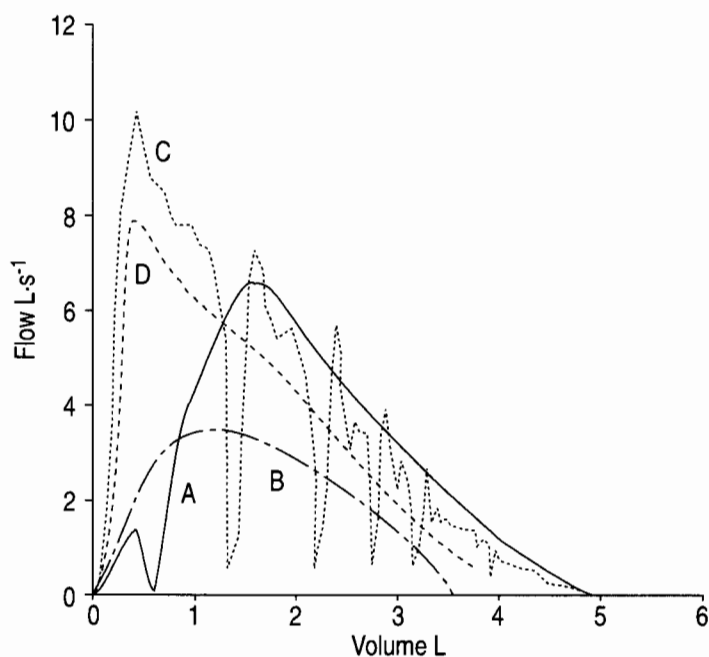


Fig. 2. – Examples of the patterns of common spirometry errors causing misclassification. A: a hesitating start (—); B: a submaximal blast (---); C: large coughs during the first second (····); D: quit too soon (-·-·-).

Table 3. – Factors to consider during interpretation of spirometry results to minimise misclassification

The pre-test probability of disease
The patient's risk factors (age, sex, symptoms, etc.)
The quality of the test session (often graded A–F)
The distance from the LLN (% predicted)
The consequences of a falsely-positive interpretation
The consequences of a falsely-negative interpretation

LLN: lower limit of the normal range.

model of office spirometer was used at all locations. The *mean* FEV₁ and FVC results were nearly identical when repeated, but the individual results differed by up to 0.4 L for FEV₁ (5–95th percentile confidence intervals) and up to 0.8 L for FVC. Furthermore, in both settings, 18% of the tests did not meet ATS standards, and the investigators concluded that perhaps their "gold standard" (testing done in PFT labs) was actually a "gilded standard". The office nurses (with a mean of 11 yrs of experience) were centrally trained using two 2.5 h courses, 1 month apart, but there was no over-reading and reporting system. The office spirometers had calibration checks done every 3 months. Spirometry training materials are available on the Internet [28] and CD-ROM [29]. The current authors recommend that professional societies develop office spirometry certification programmes for nurses and technologists, which are based on practical knowledge and demonstrated performance of good quality spirometry tests.

The accuracy of a test for screening or case-finding is measured in terms of two indices: sensitivity and specificity. A test with poor sensitivity will miss cases, producing falsely negative results, while a test with poor specificity will result in healthy persons being told that they have the disease (a falsely positive result). The sum of the false negative rate and the false positive rate is the overall misclassification rate. Five per cent is usually considered an acceptable misclassification rate for most medical tests; thus one in twenty patients will get an inaccurate interpretation of the test results. See table 3 for factors to consider during the interpretation of spirometry results to minimise the risk of misclassification. See table 4 for a list of methods to minimise the misclassification rate.

A recent recommendation suggests that 70% is used as the lower limit of the normal range (LLN) for the ratio FEV₁/FVC [30]. However, use of a fixed LLN will increase the

Table 4. – Tips for interpreting office spirometry results

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1. Poor quality test sessions often cause diagnostic misclassifications.
 2. First look at the pattern of the curves, then the numbers to confirm your impression.
 3. A bowl or rat's tail shaped flow–volume curve suggests airways obstruction. A low ratio confirms airway obstruction.
 4. A normal flow–volume curve looks like a sail, rising rapidly to a peak, then descending at about a 45 degree angle.
 5. If the volume–time curve stops before 6 s and doesn't reach a flat plateau, the FVC (and FEV₆) are underestimated.
 6. A low FVC with a normal ratio suggests restriction without obstruction. Restriction may be verified by measurement of total lung capacity.
 7. In a patient with respiratory symptoms, airway obstruction with an FEV₁ which increases by >12% (and >0.2 L) suggests asthma.
 8. In a patient with intermittent respiratory symptoms, the lack of airway obstruction, or the lack of a bronchodilator response do not rule out asthma.
 9. Airway obstruction in an adult smoker is usually (but not always) due to COPD.
 10. After spirometry, if you remain uncertain of the diagnosis, consider a diffusing capacity test (for emphysema or interstitial lung disease) or a methacholine challenge test (for asthma).
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FVC: forced vital capacity; FEV₆: forced expiratory volume in six seconds; FEV₁: forced expiratory volume in one second; COPD: chronic obstructive pulmonary disease. Adapted from [68].

misclassification rate when detecting airflow limitation. Instead, the LLN should be age and sex-specific. All published population-based studies of spirometry show that the ratio decreases with age in the healthy subset of the population, suggesting that aging alone causes slightly progressive airflow limitation (fig. 3). While 70% is about right for a 50-yr-old male, the 5th percentile LLN for a 20-yr-old is about 75%, and for an 80-yr-old 65%. The use of a fixed 70% threshold causes considerable misclassification when applied to either young adults (where the false-negative rate becomes high) or elderly adults (where the false-positive rate becomes high) [31].

Accept uncertainty

Clinicians much prefer to view test results as black-or-white, abnormal or normal, but such a stubborn stance increases the misclassification rate. Results that are near the rather arbitrary threshold (the LLN) should instead be interpreted with uncertainty (fig. 4). For instance, if the LLN for the FEV₁/FVC is 73% and the patient's ratio is 72, it should not be stated with confidence that a smoking patient has airflow limitation and COPD. On the other hand, if the patient's ratio is 55% (and the patient's FEV₁ is 60% pred) even if the quality of the spirometry test was suboptimal, one can state with confidence that the patient has COPD. Changes in the FEV₁ due to therapeutic interventions which are near the threshold of clinical significance should also be considered "borderline" (of uncertain significance).

The 2003 Global Initiative for Obstructive Lung Disease (GOLD) document correctly emphasises that "maximal patient effort in performing the test is required to avoid errors in diagnosis and management" and that "the supervisor of the test needs training in its effective performance" [30]. The National Lung Health Education Program (NLHEP) document goes much further by requiring that office spirometers incorporate software that automatically checks manoeuvre acceptability and then checks for repeatable FEV₁s and FVCs before the test session is considered complete [10]. It also recommends that manufacturers take an active role to enable office staff to learn how to use their

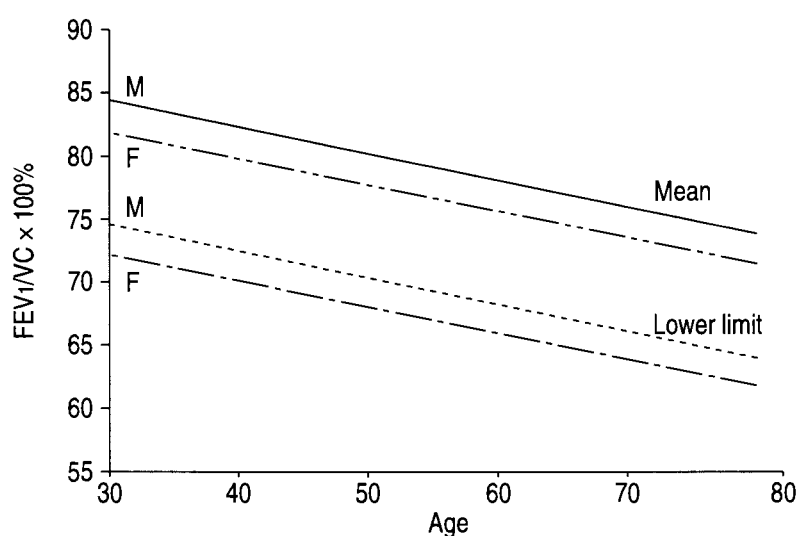


Fig. 3. – The forced expiratory volume in one second (FEV₁)/forced vital capacity (FVC) decreases with age (figure shows normal (predicted) FEV₁/VC from the third National Health and Nutrition Examination Survey (NHANES III)). Using a fixed ratio (like 70%) to determine airway obstruction will cause misclassification in young people and the elderly. M: male; F: female.

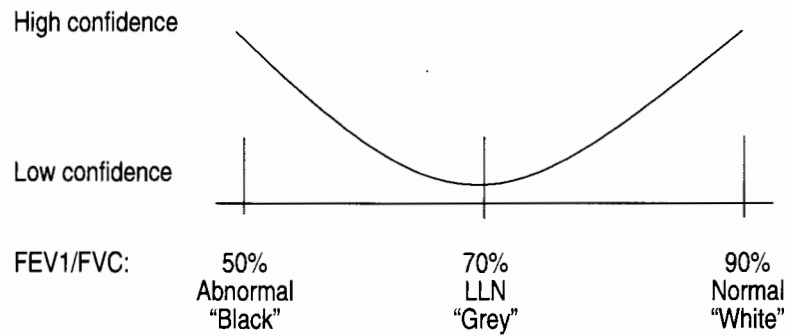


Fig. 4. – Confidence in spirometry interpretation should be low when the forced expiratory volume in one second (FEV₁)/forced vital capacity (FVC) (or the vital capacity) are near the lower limit of the normal range (LLN).

spirometer by providing easy-to-understand educational materials, such as audio-visual aids.

Spirometry for finding cases of chronic obstructive pulmonary disease

The authors recommend office spirometry for COPD case-finding when the following five factors are true: 1) an adult patient is seen in a healthcare setting; 2) the patient is a current or former smoker, especially those with any respiratory symptom (chronic cough, phlegm, wheezing, or dyspnoea on exertion); 3) good quality spirometry is carried out; 4) the result is interpreted correctly; and 5) the patient is referred to an effective local smoking cessation programme [32, 33]. Undiagnosed airflow limitation (airway obstruction) is common in the general population, is associated with impaired health and functional status [3, 34–36], and is an independent predictor of morbidity and mortality [37]. Airflow limitation due to smoking is unusual at age <40 yrs. The presence of any respiratory symptom doubles the risk of airflow limitation [38]. Simple measurement of peak flow cannot substitute for spirometry, either for detecting airway obstruction or determining its severity [39, 40].

The most common causes of airway obstruction are asthma and COPD [1, 31]. While almost all hospitals have a PFT laboratory, and almost all pulmonary specialists own a spirometer, the current authors estimate that <50% of general practitioners actively use spirometry in their practice. In the USA, the NLHEP promotes the appropriate use of spirometry by general practitioners for the detection of COPD in smoking adults [10]. However, "screening" for COPD remains controversial [42–45] since it has not yet been proven that the staff in the offices of general practitioners can attain the same low misclassification rate as experienced and certified pulmonary function technologists who perform spirometry in a laboratory setting [39, 40].

Relatively healthy workers between the ages of 40–50 yrs are less likely than older adults to visit a physician. Spirometry performed in the workplace setting may detect COPD in this age group more frequently than waiting for them to be seen by a physician. Another alternative is to invite smokers in this age group to call for an appointment for spirometry testing at a convenient clinic or pulmonary function laboratory. In one such study, COPD was detected in about one-quarter of those who responded [46].

There is a difference between using medical tests for *screening versus case-finding*. An example of screening is a booth at a city festival or sporting event which offers to perform

spirometry for anyone who is interested [47]. An example of case-finding is a physician who performs spirometry during an office visit for a patient with an unrelated disorder, such as hypertension. For example, the review of systems of a 50 yr-old female patient may disclose current smoking and a chronic morning cough, a combination of COPD risk factors that provides a clinical indication for spirometry testing. The physician then discusses the spirometry results with her and refers her to a local smoking-cessation programme. Spirometry for COPD case-finding in adult cigarette smokers fulfills all of the standard criteria for application of medical test for screening [48]; however, the evidence for two of these criteria remains weak. While spirometry is indeed accurate in the PFT lab setting (has a low misclassification rate), this may not be true in some outpatient settings [49]. It has been shown that adding spirometry to an optimal smoking cessation programme statistically significantly increases the subsequent 12 month smoking cessation rate [50–52]. Although the slightly higher rate may not be noticed by a single general practitioner [53], even a 2% improvement in smoking-cessation rates (for example, from 10% to 12%) would result in a very large absolute number of lives saved every year in a single country [54]. Of course, primary prevention of COPD, by prompting children to avoid becoming addicted to cigarette smoking and reducing workplace air pollutants, is even more important than secondary prevention efforts such as case-finding.

Potential adverse effects of screening for chronic obstructive pulmonary disease

There are tangible and intangible costs of any medical test. Adverse effects may occur due to: 1) the procedure itself; 2) the investigation of abnormal results; or 3) the treatment of detected abnormalities or diseases [48]. The economic cost of spirometry includes the cost of the instrument and the cost of personnel time (both training and testing). Office spirometers currently cost about €1,000 and about €10 of time per test is spent for testing (including initial training time) and disposable supplies. The authors estimate that accurate office spirometers will soon cost <€500. There are no adverse side-effects from the test itself, other than occasional minor discomfort that lasts for a few minutes.

Investigation and confirmation of abnormal spirometry results consumes both time and money, and may result in psychological and social harm to a few. The cost of diagnostic spirometry to confirm airflow obstruction, when performed in a hospital-based PFT lab is substantial. The estimated travel time, waiting time, and testing time spent by the patient ranges from 1 h to 3 h. The possible psychological impact of being labeled as "ill" by self and others related to false positive or even true positive test could lead to alterations in lifestyle, work, and seeking medical attention. Another important potential adverse effect is the unmeasured risk of reinforcing the smoking habit in some of the four out of five adult smokers who are told that they have normal spirometry. However, physicians should counteract this possibility by taking the opportunity to tell the patient that although spirometry was normal, their risk remains high of dying from a heart attack, lung cancer, and other smoking-related diseases; therefore, smoking cessation remains very important.

The risk of an adverse effect caused by smoking cessation is very small, and the side effects of nicotine replacement therapy and bupropion are minor. Successful smoking cessation leads to an average increase in body weight [55], but the slight increase in medical risk from minor weight gain is far exceeded by the benefits due to reduced morbidity and mortality. On the other hand, if long-acting bronchodilators or

corticosteroids are inappropriately prescribed, the cumulative cost is high and the potential side-effects can be very serious in elderly patients [56–58].

The chronic obstructive pulmonary disease action plan

Early intervention following early identification of lung function abnormalities can lead to improved smoking cessation, workplace or home environmental changes, and increased awareness and attention to cancer, cardiac and other nonpulmonary health issues associated with abnormal lung function. Early identification of airway obstruction in relatively asymptomatic patients may provide "teachable moments" when the patient has an increased awareness and response to medical education and intervention [59]. The patient is more likely to consider smoking cessation again.

Once an abnormality has been detected, an action plan must follow. Repeat spirometry should be performed to confirm abnormal office spirometry prior to initiating an expensive work-up, or when considering interventions with negative economic consequences (such as expensive medications or a recommendation to change jobs). When airway obstruction is identified in a smoker, the primary intervention is smoking cessation, since it is currently the only intervention that has been demonstrated to halt rapid decline in lung function, and thereby reduce the risk of disabling COPD [58]. In smokers with airway obstruction but without dyspnoea on exertion, smoking cessation is the only intervention with proven value. Referral to a subspecialist for further diagnostic testing should be considered in some cases. In the event that a patient with airway obstruction continues to smoke cigarettes, renewed/increased effort to assist with smoking cessation is essential [60].

Spirometry for confirming and managing asthma

Asthma is very common at all ages, and the symptoms are often overlooked or mistakenly attributed to other problems. Asthma is a disease of airway inflammation, airway hyperresponsiveness, and intermittent airway obstruction. Office spirometry can easily detect airway obstruction in a patient with asthma who presents to a primary care practitioner with respiratory symptoms such as chronic cough, chest tightness, or wheezing [61]. The FEV₁ (compared to the predicted value) may then be used to help classify the severity of asthma [7].

Since the airway obstruction of asthma is intermittent, a normal FEV₁/FVC during a single visit does not rule out asthma: referral for an inhalation challenge test should then be considered to confirm or rule out asthma. If baseline spirometry shows airway obstruction, it should then be repeated 10–15 min after inhalation of salbutamol, to detect bronchodilator responsiveness. An increase of at least 12% and 0.2 L in the FEV₁ (baseline or predicted) helps to confirm asthma [6] and predicts a good response to asthma therapy; however, the lack of acute improvement with bronchodilator inhalation does not rule out asthma. A clinical trial of asthma controller medication (4–8 weeks) should be considered, with repeat spirometry at the follow-up exam.

Office spirometry for measurement of treatment responses

An important goal of asthma management is to keep lung function close to the patient's personal best value (the green zone of good control). Asthma controller

medications should be stepped up to reach this goal and then stepped down, while monitoring to ensure that the patient remains in the green zone. No single asthma controller medication works well for *all* patients with asthma. Some patients may not respond to inhaled corticosteroids; some do not respond to leukotriene antagonists; while others do not respond well to long-acting bronchodilators [62]. This means that objective evidence for the effectiveness of these expensive medications (some with serious side-effects) should be sought during follow-up visits. Spirometry should be used to supplement the results from an asthma diary and responses to questions about the frequency of nocturnal awakenings and need for rescue medication. An improvement of >15% in FEV₁ from one visit to the next is clinically significant. Changes in peak flow are less sensitive and less specific for detecting change in lung function when compared to following changes in the FEV₁ [63].

Spirometry is also useful for determining the response of bronchodilator therapy given for relief of dyspnoea in patients with COPD. Improvement in the FEV₁ remains a primary outcome measure for most COPD clinical trials [64]. An improvement of more than 0.3 L in FEV₁ from one visit to the next is outside of the noise of measurement [65] and clinically significant in patients with mild-to-moderate COPD (an FEV₁ above 50% pred). However, following changes in the FEV₁ is probably not helpful in individual patients with COPD whose FEV₁ is severely reduced (below 1 L).

Examples of spirometry testing programmes

A national programme of early diagnosis and prevention of COPD in Poland has been reported [66]. It started in 2001 in 12 cities, where over 11,000 ever-smokers were tested in pulmonary outpatient clinics. About one-fourth of those tested had airflow limitation (10% mild, 10% moderate, 5% severe). They were all given advice to stop smoking by a physician. About 9% had the nonspecific pattern of a low FVC without airway obstruction. Two-thirds of the participants returned for a follow-up visit about 12 months later [52]. Half of those who returned had airflow limitation during their baseline exam. The biochemically verified 12 month smoking-cessation rates showed that those with moderate-to-severe airflow limitation were twice as likely to have quit when compared to those without airway obstruction (17% *versus* 8.4% quit rates). The independent predictors of success were a late start of smoking, older age, fewer pack-years, and a lower FEV₁. There was no sex difference in quit rates.

Two programmes of asthma and chronic obstructive pulmonary disease screening were completed in The Netherlands [53, 67]. From two semi-rural general practice offices, spirometry testing was carried out for 651 adult current smokers. According to American Thoracic Society criteria, 85% had acceptable test session quality, and of those, 18% had an abnormally low forced expiratory volume in one second. Patients reporting a chronic cough were about twice as likely as the other smokers to have abnormal spirometry; and nearly half of the smokers >60 yrs had abnormal spirometry. The authors estimated that in each practice, when one adult smoker was tested every day, one case of chronic obstructive pulmonary disease was found per week.

Summary

Office spirometry in the primary care setting can be most helpful for the detection (case finding) and management of asthma and chronic obstructive pulmonary disease

(COPD). The severity of asthma is underestimated by history and physical examination alone in some patients. Only spirometry has been shown to detect COPD in its early stages. The cost and side-effects of medications for asthma and COPD drives the need for objective measurement of their response, by measuring the forced expiratory volume in one second during follow-up visits. The value of population-based screening for these diseases needs further evidence. The new generation of office spirometers are less expensive, include quality checks, and make spirometry easier using six second manoeuvres. However, enthusiastic coaching for correct breathing manoeuvres remains important to reduce the risk of misclassification, which is substantial in the primary care setting.

Keywords: Airflow limitation, airway obstruction, asthma, chronic obstructive pulmonary disease, smoking, spirometry.

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