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Office spirometry

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Chronic lung diseases carry a significant amount of morbidity and mortality. Obstructive lung diseases in particular are the fourth leading cause of death in the United States. Easily implemented in the primary care office, spirometry is a portable and useful tool to diagnose and monitor patients with chronic lung disease. The main goals of office spirometry are to measure a patient's ability to exhale forcefully, and to distinguish obstructive from restrictive lung disease. Indications include to evaluate the signs or symptoms of possible lung disease, to assess effectiveness of treatment for lung disease, and to follow-up or monitor progression of lung disease in primary care or in occupational health patients. It may also be used to assess a patient's baseline lung function if needed for insurance purposes or by some employers as part of pre-employment screening. Basic requirements to perform office spirometry are a well-trained operator, a suitable patient, and spirometry equipment that meets or exceeds the American Thoracic Society's standards for office spirometers. Interpretation of spirometry results should always be done in the context of the patient's clinical picture and never as isolated values that may or may not fall within the range of normal. Results obtained in the office can be analyzed to determine if the patient has obstructive, restrictive, or mixed lung disease, or if any airway obstructions are present. The test can also be repeated after the administration of a bronchodilator to determine if significant bronchodilation is present. Spirometry data can be monitored over time to optimize therapy and assess progression of patients with chronic lung disease.

Overview

Obstructive lung diseases, including chronic obstructive pulmonary disease (COPD), asthma, emphysema, and chronic bronchitis, as well as restrictive lung diseases, such as pulmonary fibrosis, carry a significant amount of morbidity and mortality. Obstructive lung disease in particular is the fourth leading cause of death in the United States, and it affects approximately 7% or more of those over the age of 50 years.[1] The incidence of COPD increases with increasing age, particularly in patients that smoke. The osteopathic family physician, as the first point of contact for patients, is in a great position to diagnose and treat chronic lung disease. Spirometry is a useful tool that can be easily implemented in the office to diagnose and monitor patients with chronic lung disease. All that is required is an office spirometer (typical cost in the range of $1500-$2500), and an operator familiar with the operation of the device and with the proper patient education prior to and during the procedure. The procedure is not time-consuming and can usually be completed during the course of a typical office visit.

Office spirometry should be billed under Current Procedural Terminology code 94010. If spirometry is done prebronchodilator and postbronchodilator then code 94060 should be reported instead. A suitable diagnosis code, such as COPD, chronic cough, or dyspnea, should accompany the claim. According to 2012 Medicare reimbursement rates,

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office spirometry reimbursement is around $36 and a prebronchodilator and postbronchodilator test will reimburse your practice around $61.

The main goal of office spirometry is to measure a patient's ability to exhale forcefully, and depending on the results of the test, to distinguish obstructive from restrictive lung disease.[2] The forceful exhalation can be expressed in terms of volume or flow. Although there are many parameters that can be measured or calculated by the spirometer, the 2 main parameters needed to interpret office spirometry are the forced vital capacity (FVC) and the forced expiratory volume in 1 second (FEV1).[3] See Table 1 for definitions of selected spirometry parameters.

In this article, we adhere to guidelines and recommendations from the American Thoracic Society (ATS) and the European Respiratory Society (ERS) task force when describing the procedure for office spirometry and the interpretation of spirometry results in adults.

Indications

Office spirometry is indicated to evaluate signs or symptoms of possible lung disease, to assess effectiveness of treatment for lung disease, and to follow-up or monitor progression of lung disease. It may also be used to assess a patient's baseline lung function if needed for insurance purposes or by some employers as part of pre-employment screening.[3]

Office spirometry could play a role in secondary prevention of smoking. There is evidence that patients who smoke and have abnormal spirometry results are more likely to quit smoking than smokers with normal results.[4] Patients who smoke should be informed that a decreased FVC is a risk factor for cardiovascular disease,[5] and that smokers with moderate to severe COPD are at increased risk of death compared to non-smokers with moderate to severe COPD.[6]

The US Preventive Services Task Force discourages the use of spirometry to screen for lung disease in asymptomatic adults.[1]

Table 1 Definitions for selected spirometry parameters

FVC	Total volume of air exhaled during a forced expiratory effort, starting from a full inspiration
FEV1	Volume of air exhaled during the first second of a forced expiratory effort
FEV1/FVC	Ratio of the volume of air exhaled during the first second of a forced expiratory effort to the total volume of air exhaled during a forced expiratory effort
TLC	Total air capacity of the lungs after a full inspiration (including lung residual volume), measured during a full pulmonary function test
VC	Maximum volume of air exhaled from a point of full inspiration
SVC	Maximum volume of air slowly exhaled from a point of full inspiration

Procedure

Basic requirements to perform office spirometry are a trained operator, a suitable patient, and spirometry equipment that meets or exceeds the ATS standards[7] for office spirometers.

Spirometry can be physically demanding and patients selected for the test should be able to undergo the procedure. Testing is done with the patient in the seated position in order to avoid the possibility of falling due to dizziness or syncope. There should be a clear indication to perform the test, and the patient has to be fully informed and educated on the procedure, including potential issues and complications. Patients should avoid smoking at least 1 hour prior to testing as well as refrain from consuming alcohol within 4 hours of testing. They should also be advised not to wear tight or restrictive clothing and to avoid eating a large meal within 2 hours of testing. Patients should not be tested within 1 month of a myocardial infarction. Spirometry should be avoided in patients with chest or abdominal pain of any cause, oral or facial pain, stress incontinence, or dementia, since these conditions will likely produce suboptimal or invalid spirometric results.[8]

If osteopathic manipulative treatment (OMT) targeting the respiratory system will be performed at the same visit, spirometry should be done prior to OMT due to concerns of possible worsening of air trapping after OMT.[9]

Each test consists of 3 basic phases: maximal inspiration, a rapid exhalation, and a continued complete exhalation. It is helpful if the operator demonstrates how to perform the test and to have the patient try out the equipment prior to the actual test.

If there is concern that the patient might become dizzy or pass out during the test, a vital capacity (VC) or slow vital capacity (SVC) maneuver may be substituted for the FVC. The VC or SVC should be obtained prior to attempting to obtain an FVC or FEV1 due to concerns for muscular fatigue or gas trapping with deep inspiration in patients with severe obstructive disease.[3] The VC or SVC is a slow and deliberate test in which the patient takes 2 or 3 normal tidal breaths and then takes a full, slow inspiration and slowly exhales completely without a forced effort.

Typically, a minimum of 3 acceptable tests are needed per spirometry session. Each test must meet end-of-test criteria to be acceptable, and each group of tests must meet repeatability and acceptability criteria. When 3 tests that meet all criteria are recorded, the spirometry session may be terminated and the data interpreted. End-of-test criteria are met if the volume-time curve for the test shows no change in volume for ≥ 1 second and the patient has exhaled for at least 6 or more seconds. Repeatability and acceptability criteria are met if the spirometer tracings are free from artifacts, the end-of-test criteria are met, and there is a difference of ≤ 0.15 L when comparing the largest and next largest values for both the FVC and the FEV1. If the patient has an FVC of ≤ 1.0 L, use 0.1 L instead of 0.15 L.[3] Most commercially available spirometers will automatically determine if a test and a series of tests meet the criteria prior to allowing the operator the option to save or discard a test run.

Once a suitable set of 3 runs is obtained, another set may be obtained after the administration of a bronchodilator, if clinically indicated, to assess for airway reversibility. The data obtained as well as the spirograms (graphs generated by the spirometer showing the inhalation or exhalation effort plotted as a function of volume/flow/s) are interpreted to determine whether the results are normal, abnormal, or equivocal.

Interpretation of spirometry results

In order to interpret spirometry results and determine if the test is normal or abnormal, 3 basic parameters are needed: FVC, FEV1, and the ratio of FEV1 to FVC. If there are values available for the SVC, and these are larger than the FVC, the SVC is to be used in place of the FVC for calculating the FEV1 to FVC ratio. The FVC is usually lower than the SVC in obstructive lung disease,[7] therefore using the largest value available for the denominator will more accurately identify those patients with true obstruction, and avoid potential underdiagnosis of obstructive lung disease.

If the test is interpreted as abnormal, the abnormal pattern should then be classified as either obstructive, restrictive, or mixed. If results are inconclusive, and there is clinical suspicion for lung disease, the patient should then be referred for a full pulmonary function test (PFT).

The spirometry data obtained should be compared to reference equations based on data from a representative population sample of healthy subjects drawn from the same ethnic population as the patient tested, adjusted for age, gender, and height. In the United States, the reference equations used for adults are obtained from the National Health and Nutrition Examination Survey III.[10] Values that fall below the lower limit of normal (LLN), that is, below the fifth percentile of normal range, should be considered abnormal. This is in contrast to using fixed cutoffs, which traditionally have been $<80\%$ for either the FVC or FEV1, and $<70\%$ for the FEV1 to FVC ratio. The practice of using fixed cutoffs for the FVC and the FEV1 have no statistical basis in adults and could overestimate the incidence of lung disease in older patients and those that have a short stature. Using a fixed cutoff for the FEV1 to FVC ratio could also overestimate the presence of lung disease, especially in older patients.[7] The implications of using the

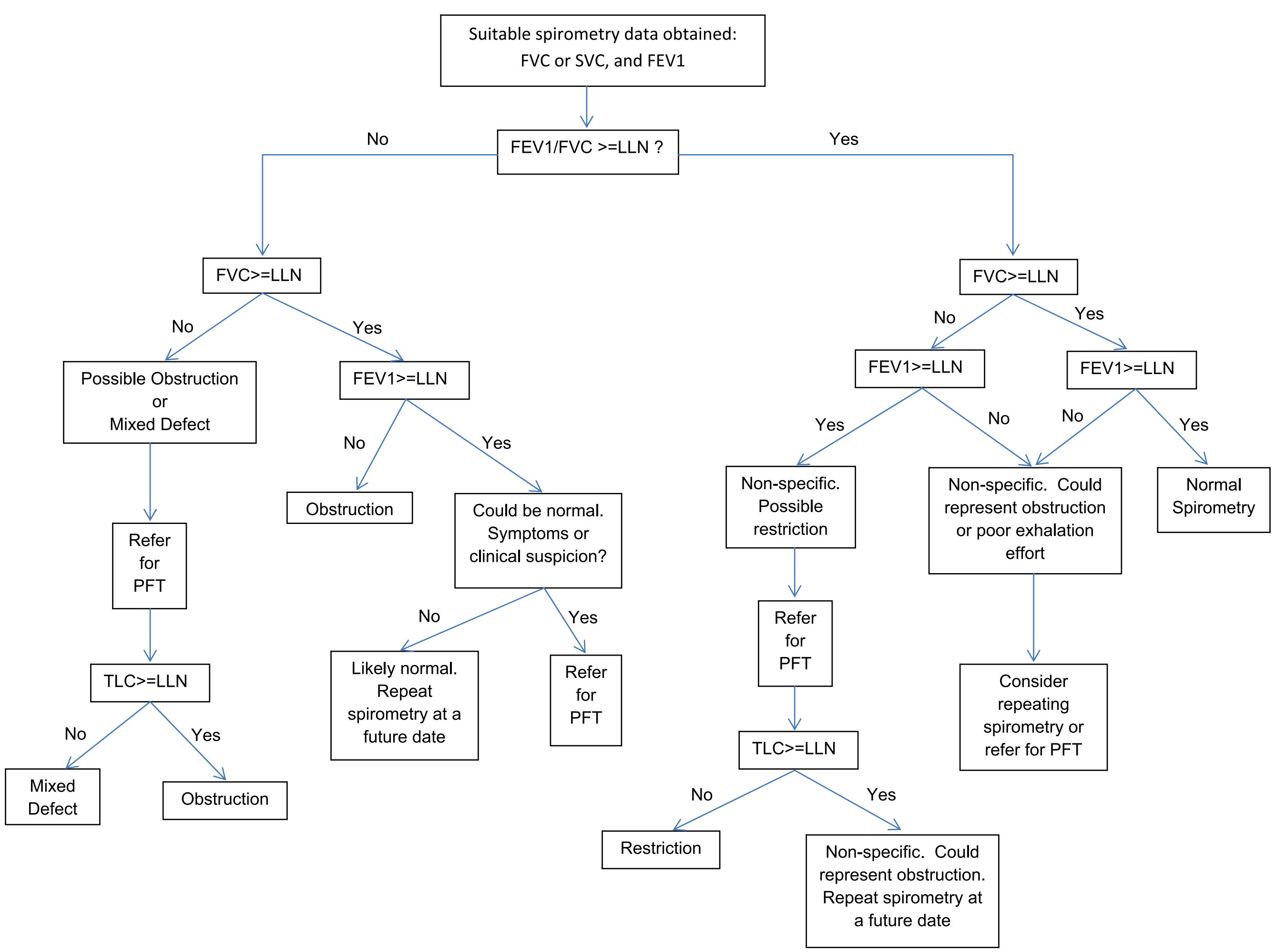

Figure 1 Algorithm for interpreting office spirometry results.

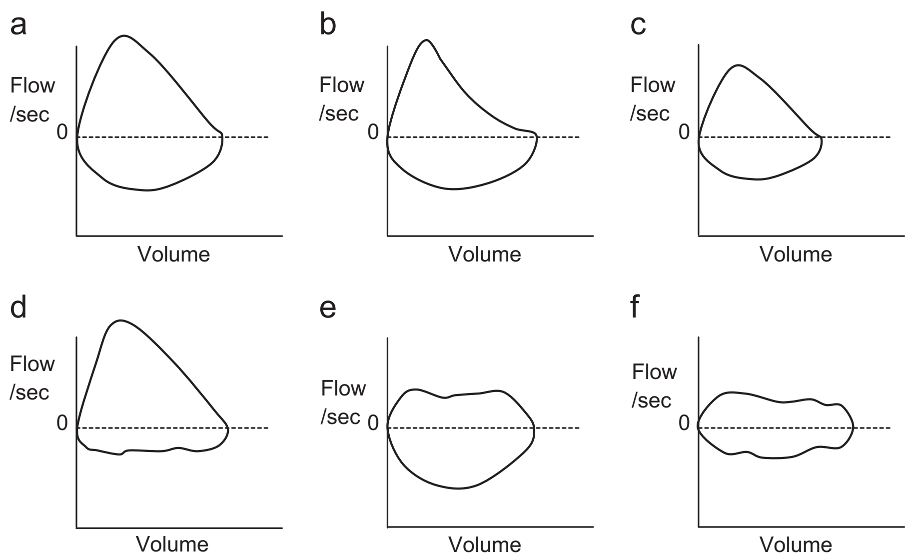

Figure 2 Representative spirograms obtained during office spirometry: (a) normal spirogram, (b) obstructive lung disease, (c) restrictive lung disease and (d) variable extrathoracic upper airway obstruction, (e) variable intrathoracic upper airway obstruction, and (f) fixed upper airway obstruction.

LLN instead of fixed cutoffs in the interpretation of spirometry results have been debated in the literature,[11–13] and if the physician interpreting spirometry results chooses to use fixed cutoffs, it should be done with knowledge of the potential limitations of that method.

Interpretation of spirometry results should always be done in the context of the patient's clinical picture and never as isolated values that may or may not fall within the range of normal. Commercially available spirometers often will automatically analyze the data obtained according to ATS or ERS criteria and flag those values that fall below the LLN.

Figure 1 presents an algorithm for interpreting office spirometry results that incorporates recommendations from the ATS or ERS guidelines. Figure 2 presents typical spirograms for common lung conditions diagnosed via office spirometry.

Types of defects

Obstructive disease

The hallmark of obstructive lung disease is an FEV1 to FVC ratio that is lower than the LLN. A reduced ratio indicates airflow narrowing during forced expiration. The spirogram typically shows a concave expiratory curve (Figure 2b).

As airway obstruction becomes more severe, the FEV1 will also be considerably reduced. However, if the FEV1 to FVC ratio is lower than the LLN and the FEV1 is normal, the results should be interpreted with caution since this pattern could be normal.[10]

An FEV1 which is lower than the LLN in the presence of a normal FEV1 to FVC ratio is nonspecific, as it could represent either obstructive disease or a poor exhalation effort.[10] Again, how results are interpreted will depend on the clinical picture and the clinician's suspicion for presence of lung disease. Repeat spirometry at a later date or PFT can be considered if results are equivocal.

The severity of obstructive disease is based on the percent reduction of FEV1 as compared to predicted (Table 2). Some conditions that lead to obstructive lung disease are emphysema, COPD, chronic bronchitis, asthma, and cystic fibrosis.[14]

Restrictive disease

The hallmark of restrictive lung disease is a reduced total lung capacity (TLC) in the presence of a normal FEV1 to FVC ratio. Since TLC is not measured in office spirometry, restriction should be suspected if the FVC is reduced and the FEV1 to FVC ratio is normal. The spirogram typically has a convex expiratory curve and is reduced in total volume compared to normal (Figure 2c).

If a restriction is suspected on clinical grounds and the FVC is normal, a PFT should be obtained to evaluate the TLC, since the presence and severity grading of restrictive lung disease are based on the TLC.

It should be noted that according to ATS or ERS guidelines, an isolated reduced FVC in the presence of a

Table 2 Severity grading for obstructive lung disease (modified from Fishman[14])

Severity grade	Percent of predicted FEV1
Mild	$>70\%$
Moderate	60%-69%
Moderate to severe	50%-59%
Severe	35%-49%
Very severe	$<35\%$

normal FEV1 and normal FEV1 to FVC is considered a nonspecific finding. If restriction is clinically suspected then a PFT should be obtained.

Some conditions that lead to restrictive lung disease are pulmonary fibrosis, severe atelectasis or pneumothorax, lobectomy, and decreased ability to take a deep inspiration such as seen in severe obesity, neuromuscular disease, rib fractures, or chest wall scarring.[14]

Mixed disease

A reduced FVC in the presence of a reduced FEV1 to FVC ratio could represent a mixed defect, where both obstruction and restriction are present. If this is the case, referral should be considered for PFT since the TLC will determine if the defect is mixed (TLC $<$ LLN) or a pure obstruction (TLC $\geq$ LLN).

Upper airway obstructions

Spirograms can provide valuable information on the presence of possible upper airway obstruction. Typical spirograms for obstructive and restrictive lung disease have already been described.

Variable extrathoracic airway obstructions, such as laryngomalacia, vocal cord dysfunction or paralysis, upper airway masses, and strictures or narrowing of the glottis, cause collapse of the upper airways during forced inspiration, and appear as a flattening of the inspiratory arm of the flow-volume loop (Figure 2d).[14]

Variable intrathoracic airway obstructions, such as tracheomalacia or hilar tumors, cause an increase in lesion size with forced expiration, and appear as a flattening of the expiratory arm of the flow-volume loop (Figure 2e).[14]

Fixed upper airway obstructions, such as narrowing of the trachea or strictures of the airways, large goiters, and tracheal tumors, are not affected by forced breathing, and appear as flattening of both the inspiratory and expiratory arms of the flow-volume loop (Figure 2f).[14]

Bronchodilator response

After completion of spirometry, if reversible airway obstruction is suspected, an inhaled bronchodilator can be administered and the test repeated. This could be useful in distinguishing asthma from chronic bronchitis or emphysema. Diseases such as asthma typically exhibit significant bronchodilation, defined as an increase in either FEV1 or FVC of at least 12% also accompanied by a volume increase of at least 200 mL.[14]

A small percentage of patients with chronic bronchitis or emphysema will exhibit significant bronchodilation. Also, bronchodilator response during spirometry does not always correlate with clinical response to bronchodilators.[10] Results, as always, should be interpreted in light of the patient's complete clinical picture.

Change over time

When performing repeat spirometry to monitor disease progression, the variables that will most consistently reflect the trend in pulmonary function are the FEV1 and FVC.[7]

A yearly decrease of 15% in FEV1 or FVC is considered clinically significant in patients with lung disease. In patients without lung disease, the change in FEV1 or FVC should exceed 15% before any clinical decisions are made, because test variability in normal patients usually exceeds the true annual decline in lung function, if present.[7] Test variability also typically exceeds the true decline in lung function in patients with very severe obstructive disease, so results over time in these patients should be interpreted with caution, particularly in the absence of worsening clinical symptoms.

Conclusions

With the proper training and equipment, office spirometry is a relatively simple way to diagnose and monitor patients with chronic lung disease. When spirometry results are properly interpreted in the context of the patient's clinical history and exam, office spirometry is an excellent point of care tool readily available to the osteopathic primary care physician.

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