



The Ins and Outs of Office Spirometry

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Spirometry is the measurement and evaluation of forced expiratory flow rates, including forced expiratory volume in one second (FEV₁) and forced vital capacity (FVC). It is a useful tool to assist primary care providers with the diagnosis and management of various respiratory problems. Spirometry can be easily and affordably performed in the office setting, although a variety of issues, including equipment maintenance, performance of expiratory manoeuvres, and accurate interpretation must be appreciated.

Who should have office spirometry?

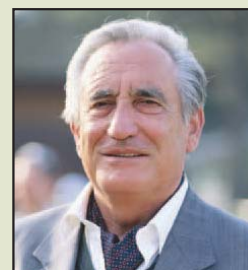
Indications for office spirometry include the assessment of symptoms (Table 1). Spirometry can also be helpful in objectively monitoring patients' response to therapy (*i.e.*, inhaled steroid or bronchodilator medication in asthma or chronic obstructive pulmonary disorder [COPD], and progression of disease). It is also useful in monitoring patients with neuromuscular disease, although the additional measurement of maximal inspiratory and expiratory pressures improve the overall utility in this setting.¹⁻³

What equipment should be used?

The majority of commercially available office spirometers meet recommended standards for accuracy. The best apparatus for obtaining a spirogram is a direct volume recording device, which usually has a rapid response time. This device is also less influenced by external factors, such as density of

Mr. Jackson's cough

Mr. Jackson, 56, presents with a two-year history of exertional dyspnea and productive morning cough. His past history is significant for pneumonia five years previously and hypertension treated with diuretics since he was 50.



He is a farmer who has an ongoing 35 pack-a-year smoking history. Functionally:

- He is able to continue his usual daily activities
- His physical examination demonstrates mild tracheal shortening
- Percussion of the chest is normal and there are no abnormal findings on chest auscultation
- The rest of his exam is unremarkable
- Routine laboratory investigation is normal
- Chest radiograph demonstrates mild hyperinflation

Although you suspect he has chronic obstructive pulmonary disease, you wonder whether there is anything else you can do to quickly and easily confirm the diagnosis.

What happened to Mr. Jackson? See page 81.

gas, or dirt and water droplets.⁴ Generally, a device must be capable of measuring flows accurately up to 12 L/sec,⁴ and may be either a portable handheld spirometer, or a spirometer which requires a computer and associated software. Generally, most spirometers include useful educational data regard-

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ing use, maintenance, calibration, and cleaning. More detailed recommendations are available through the American Thoracic Society (ATS).¹

How should a spirometer be taken care of?

Calibration of an office spirometer includes periodic mechanical calibration and biologic calibration. Mechanical calibration is performed with either a 3 L pump or a smaller 1 L syringe. The frequency of calibration varies depending on the type of spirometer, however, spirometers should generally be calibrated daily. Biologic calibration requires a human control (without lung disease) to perform FEV₁ and FVC measured daily for a 10-day period. The range (largest minus the smallest value) should not exceed 10% of the average of all measurements.^{1,2}

Other elements of equipment quality control include regular assessment for leaks in the system, which is done by applying 3 cm water pressure with the spirometer opening occluded for at least one minute. As well, spirometer linearity should be assessed on a quarterly basis for volume spirometers, and weekly for flow spirometers. Finally, assessment of the mechanical time recorder scale accuracy should be performed on a quarterly basis with a stop watch.^{1,5} These details should be provided by the manufacturer with the spirometer at the time of purchase, and followed closely to ensure valid and accurate measurements.

Technician cleanliness is important, and routine hand washing between tests is indicated. A new or sterilized mouthpiece and filter should be used for each subject. Filters are particularly important when inspiratory flows are being performed. Subjects with suspected or active pulmonary tuberculosis should not be allowed to perform spirometry. It is essential that physicians who are overseeing the use of spirometers read and follow the manufacturers' data regard-

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Table 1

Indications for office spirometry

Symptoms

- Dyspnea
- Cough,
- Chest pain,
- Wheezing

Individuals, at risk of pulmonary disease, to screen:

- Smokers (asymptomatic or symptomatic)
- Those with occupational exposure to respiratory toxins

Evaluation of abnormal chest radiographs:

- Monitor response to therapy
- Monitor progression of disease
- Monitor patients with neuromuscular disease

ing instructions about cleaning technique and frequency of cleaning required.^{1,2}

How should spirometry be performed?

Since spirometry is an effort-dependent manoeuvre, proper performance requires a cooperative subject who understands and is able to coordinate the expiratory and inspiratory manoeuvres. Sub-maximal effort is a major cause of test inaccuracy and imprecision. After the subject's height, weight, age, sex, and gender have been entered, the technician supervising the test must instruct and encourage the subject to perform the manoeuvres properly. It has been proposed that the manoeuvre can be broken down into four stages (Table 2).

Ideally the forced expiratory and inspiratory manoeuvres should be performed in an erect seated position with both feet planted on the floor.

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Table 2

Stages of spirometry

Stage 1:

Tell the subject to take as deep a breath as possible

Stage 2:

Loudly instruct the subject to blow into the spirometer forcefully

Stage 3:

Continue to prompt the subject to continue exhaling for several more seconds, until they no longer can.

To obtain full flow-volume loops, a fourth stage should be taken. This should be done when the patient has completed the forced vital capacity manoeuvre.

Stage 4:

Instruct the patient to take a second deep breath, to total lung capacity.

Adapted from: Enright PL: Office spirometry. Up To Date 2002;Version 11.2.

Table 3

Guidelines for severity of airflow obstruction

Mild	FEV ₁ 60% to 79% predicted
Moderate	FEV ₁ 40% to 59% predicted
Severe	FEV ₁ < 40% predicted

FEV: Forced expiratory volume

Adapted from: Canadian Thoracic Society. Recommendations for management of chronic obstructive pulmonary disease – 2003. Can Respir J 2003;10 (Suppl A):11A-33A.

What is an acceptable result?

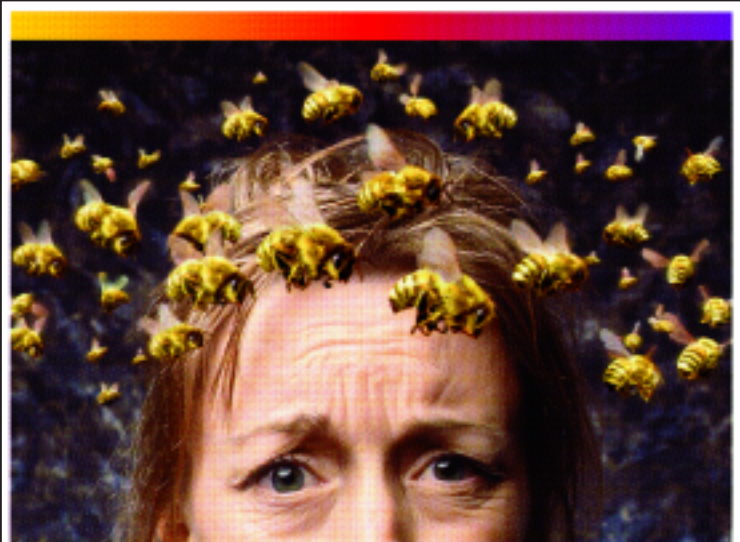
FEV manoeuvres should be performed a minimum of three times and a maximum of eight times. A flow is considered acceptable if it is free of artifacts (*e.g.*, cough or glottis closure, early termination, variable

Mr. Jackson's Followup

Followup

The patient undergoes office spirometry during the current office visit. Post-bronchodilator spirometry shows the FEV₁ is reduced to 70% predicted with only 5% reversibility. The FEV₁/FVC ratio is reduced to 0.65. The diagnosis of mild COPD is confirmed, and the patient is counselled regarding smoking cessation. He is started on a short-acting bronchodilator on an as-needed basis with improvement in symptoms. Followup is arranged for one month's time.

Alternately, a standing position can be used, although this should be documented since it has been observed that the FEV₁ is larger in standing patients.⁶ A nose clip should be used to prevent unnecessary air leaks during the procedure.¹ Generally, if the manoeuvres are performed properly, two further tests are performed and the best values are recorded.



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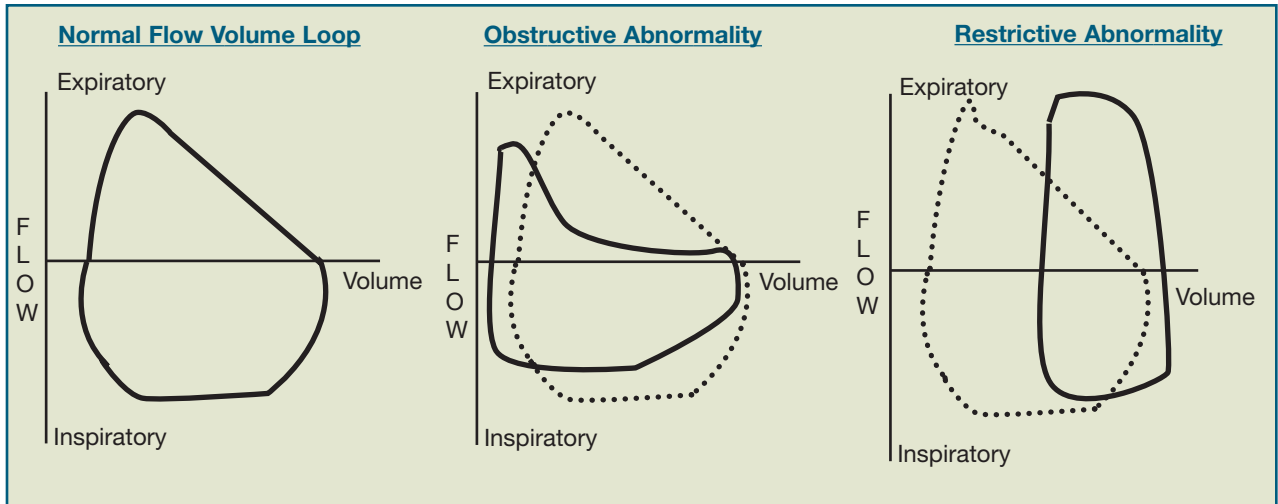


Figure 1. Flow volume curve examples (normal, obstruction, restriction).

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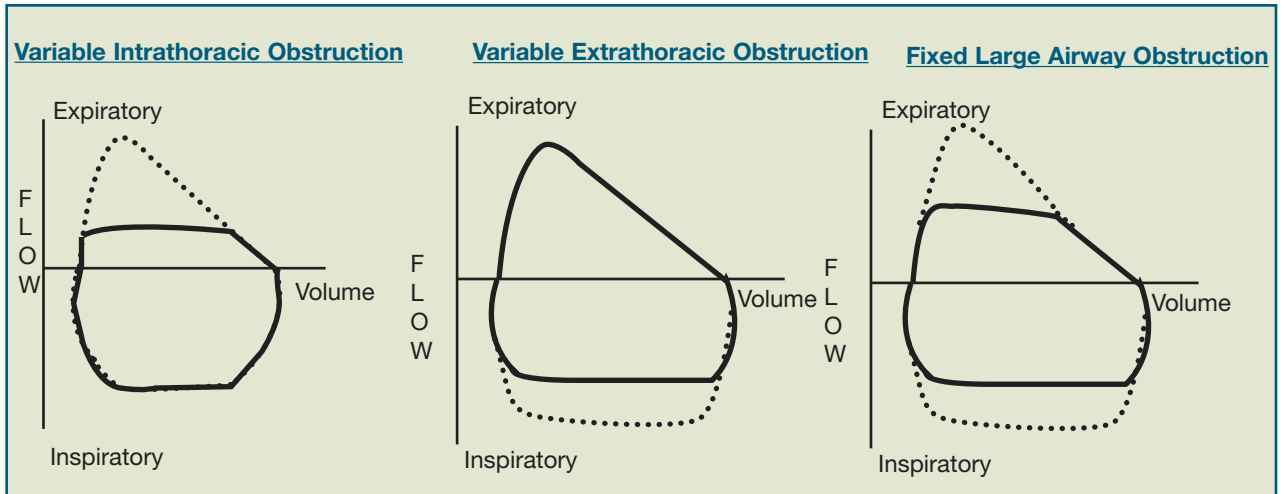


Figure 2. Normal, obstructive, and restrictive flow volume loops.

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effort, leak), has an adequate start (*i.e.*, began from total lung capacity), and has a satisfactory exhalation time. The ATS recommends that in order to obtain an acceptable FVC, the expiratory manoeuvre be performed for a minimum of six seconds.¹ In normal individuals or those with mild disease, six seconds is the point when a plateau in the volume-time curve is achieved. In subjects with more severe disease, a plateau may not be reached until long after six seconds of expiratory flow, therefore these patients should continue the FVC maneuver until a plateau is reached.

Once the flow is considered “acceptable,” further tests are performed. The repeated efforts must also meet ATS reproducibility criteria, which include the following:

- The two largest FVCs must be within 0.2 L of each other.
- The two largest FEV₁s must be within 0.2 L of each other.

If the subject’s first three flows meet the ATS reproducibility criteria and are of acceptable quality, the best results are recorded. Otherwise, further expiratory flows must be performed until the criteria are met. A maximum of eight maneuvers are performed, unless the subject is unable to perform any more due to fatigue.¹

How should results be interpreted?

Interpretation should be made in light of the clinical question posed. Borderline “normal” results should be interpreted cautiously, particularly if problems with reproducibility or accuracy have been an issue. The most useful results necessary for interpreting spirometry include the measurements of FEV₁, FVC, and FEV₁/FVC ratio.

Results are given as absolute values, and as a percentage of predicted value based on previously established reference values. An FEV₁ or FVC value of less than 80% predicted is considered to be abnormal.

Spirometry itself will not diagnose specific dis-

eases, but will help to identify patterns of dysfunction. These include either “normal” or “obstructive” (*i.e.*, COPD or asthma). A third pattern, “restrictive,” can be suggested by spirometry, although a definitive diagnosis of restriction requires full pulmonary function testing (which also includes lung volume measurements).

Flow volume loops, if available, can also be helpful in establishing a pattern of dysfunction (Figure 1). Diseases affecting the large intrathoracic or extrathoracic airways can also be identified from flow volume loops as a “table-top” flattening of the inspiratory or expiratory flow volume loops (Figure 2).

The FEV₁/FVC ratio is more precise in identifying whether there is an obstructive or non-obstructive pattern. An FEV₁/FVC ratio of less than 0.7 is diagnostic of obstruction, particularly if the FEV₁ is also reduced below 80% of predicted.⁶ A positive bronchodilator response after the administration of two puffs of short-acting beta agonist requires an increase of 12% and 200 mL from the pre-bronchodilator measurement in either FEV₁ or FVC.⁷

Take-home message



What do you use a spirometer for?

- Spirometers assist primary care providers with the diagnosis and management of various respiratory problems.
- Spirometry itself will not diagnose specific diseases, but will help to identify patterns of dysfunction.
- Indications for office spirometry include the assessment of symptoms, such as dyspnea, cough, chest pain, and wheezing.
- The best apparatus for obtaining a spirogram is a direct volume recording device, which usually has a rapid response time, and is less influenced by external factors.

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A positive bronchodilator response may be seen in either asthma or COPD, although clinical assessment must be undertaken to make a definitive diagnosis. An increased FEV₁/FVC ratio may suggest a restrictive pattern, particularly if the FVC is reduced below 80%.⁸ The severity of airflow obstruction is based on the FEV₁. This may differ from the severity of clinical disease. The recently published Canadian Thoracic Society⁷ guidelines on the management of COPD have proposed new criteria for severity of airflow obstruction (Table 3).

Inaccurate results may occur for a variety of reasons, including:

- poor spirometer calibration and maintenance;
- the subject's inability to perform correctly; and
- incorrect result selection or recording.

Results may also be affected by patient technique, particularly if the patient does not reach total lung capacity before performing FEV₁, or does not finish the FVC manoeuvre to residual volume. Also, data must be corrected for body temperature, ambient temperature, and saturation of water vapour. Most diagnostic spirometers are equipped to record this data automatically. Failure to do this may lead to false results.¹⁻³

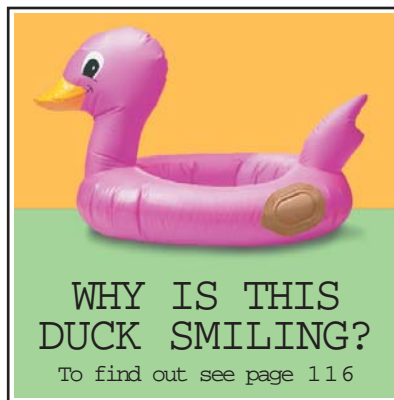
Who should be referred for further testing?

Patients with abnormal spirometry, which shows an obstructive abnormality, may be referred for full pulmonary function testing. This includes repeat spirometric evaluation, as well as static lung volumes (total lung capacity, vital capacity, functional residual capacity, and residual volume), and measurements of diffusing capacity. Patients with a pattern suggestive of a restrictive abnormality should have further testing performed. As well, patients who continue to com-

plain of respiratory symptoms that cannot be explained with office spirometry and routine workup (including history, physical, laboratory, and radiographic evaluation) should also be referred for full pulmonary function testing. [CME](#)

References

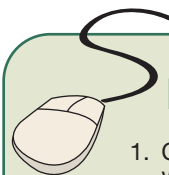
1. American Thoracic Society: Standardization of spirometry: 1994 update. *Am J Respir Crit Care Med* 1995; 152(3):1107-36.
2. Ferguson GT, Enright PL, Buist AS, et al: Office spirometry for lung health assessment in adults: A consensus statement from the National Lung Health Education Program. *Chest* 2000;117(4):1146-61.
3. Petty TL: Simple office spirometry. *Clin Chest Med* 2001; 22(4):845-59.
4. Pride NB: Tests of forced expiration and inspiration. *Clin Chest Med* 2001; 22(4):599-622.
5. Morris AH et al: Intermountain Thoracic Society: Clinical pulmonary function testing. Second Edition. Intermountain Thoracic Society, Salt Lake City, 1984.
6. Townsend MC: Spirometric forced expiratory volumes measured in the standing versus the sitting position. *Am Rev Respir Dis* 1984; 103:123-4.
7. Canadian Thoracic Society. Recommendations for management of chronic obstructive pulmonary disease, 2003. *Can Respir J* 2003;10 (Suppl A):11-33.



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