Why Perform Pulmonary Function Tests?

James G. Martin, MD, DSc

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Respiratory disease occupies a substantial part of primary care medicine. Medical visits for cough, production of sputum, shortness of breath, chest pain and other respiratory symptoms are frequent. The evaluation of such symptoms should be accompanied by routine simple lung function testing. The spirometer was developed > 100 years ago for the purpose of diagnosing TB through the detection of a reduced lung size. From these early studies by Hutchinson, the volume of air that could be expelled from the lungs after a maximal inspiration, the vital capacity, came into being. Subsequently, the timed vital capacity was invented and the forced expiratory volume in one second (FEV_1) was proposed as a method for the detection of reduced airflow. It was a small step to use the ratio of FEV_1 to the forced vital capacity (FVC) to correct the FEV_1 for lung size.

The information that can be derived from the spirometer remains the most useful in clinical practice. However, it is grossly underutilized despite the ease of its performance and the availability of convenient commercial devices to make the measurements. The underdiagnosis of asthma, chronic obstructive lung disease from smoking and other pathologies are the result. Reliance on clinical signs such as wheezing, alterations in breath sound intensity or quality and prolongation of expiration is a mistake. Substantial pathology may be present in the absence of clinical signs.

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In complex pulmonary pathologies, such as interstitial pulmonary fibrosis, a more detailed assessment of lung function (pulmonary function tests [PFTs]) and exercise performance is indicated and referral to a pulmonary function laboratory is necessary.

A well-equipped pulmonary function laboratory offers:

- Measurement of lung volumes and diffusing capacity
- Exercise testing
- Bronchial provocation testing
- Respiratory muscle strength/diaphragmatic strength

Table 1
Pulmonary function test [PFTs] results

	Predicted	Measured	% predicted
Forced expiratory volume in one second (FEV_1)	4.21	2.75	65
Forced vital capacity (FVC)	5.30	3.02	57
FEV_1/FVC	78%	86%	
Total lung capacity	7.36	4.29	58
Functional residual capacity	2.85	1.56	55
Residual volume	1.67	1.01	60
Diffusing capacity of the lungs for carbon monoxide	39.2	15.9	41

Remember neuromuscular disease may cause loss of lung function through impairment of inspiratory and/or expiratory muscle strength.

Interpretation of spirometry

Generally, when measurements fall < 80% of the predicted values, abnormality is present. Abnormal spirometry is characterized as either:

- Obstructive when FEV_1/FVC is low (< 75% usually but normal values are higher for women and in young persons)
- Restrictive when FVC is low but FEV_1/FVC is normal or even supranormal

Restriction always requires confirmation with complete PFTs that should show a low total lung capacity (TLC). When spirometry is obstructive, two to four inhalations of salbutamol and repeat testing 15 minutes later may demonstrate reversibility (> 12% increase in FEV_1 and > 200 mls in absolute terms) and allow a diagnosis of asthma to be made. The failure to show reversibility in this manner, of course, does not rule out asthma.

Case 1

A 49-year-old male engineer and non-smoker presents with a two-year history of progressive shortness of breath on exertion. He had no sputum or wheezing. He experienced pains in his chest while eating and was told he had esophageal dysmotility. He had mild hay fever and had cats at home. He has no prior history of asthma. Physical exam was normal. Chest x-ray (CXR) showed small lungs and subtle nodular interstitial changes at the left base. EKG was normal. PFTs were performed (Table 1).

What have we learned?

The tests show a typical restrictive pattern with a low TLC, a low functional residual capacity and a low residual volume. Stiff lungs secondary to pulmonary fibrosis cause this pattern of change. The diffusing capacity is disproportionately low and even if arterial oxygen partial pressure is normal at rest, there is a high probability that it will fall on exercise when diffusing capacity is substantially reduced.

A lung biopsy was performed and areas of mature and immature fibrosis were found. The creatine kinase was elevated in the blood and a diagnosis of polymyositis was made. Steroids were administered with good effect and the patient was followed with PFTs ordered at intervals of three months at first and six to 12 months subsequently.

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Case 2

A 37-year-old man presents with a chronic cough, worse at night and is often awakened from sleep with a sense of chest tightness. He has not noted wheezing, although on several occasions in the past he was told he had bronchitis and was treated with antibiotics. After colds he coughed for up to eight weeks or so before it resolved. He also coughed after he laughed. Auscultation of the chest was normal as was the CXR. Routine PFTs were within normal limits.

Dr. Martin is a Professor of Medicine, Respiratory Division, Department of Medicine, McGill University, Montreal, Quebec.

What's next?

Do you change antibiotics or give a repeat course of antibiotics in the belief that the infection had not been cleared? He was sent for a methacholine challenge test which is a quantitative measurement of airway responsiveness (twitchiness). The test showed that he had a fall in FEV_1 of 22% at a concentration of inhaled methacholine of 2 mg/ml. Any person whose FEV_1 falls by ≥ 20% at a concentration of methacholine of ≤ 8 mg/ml, has a positive test and is at risk for symptoms of asthma. When symptoms are present and the person has a positive test, then asthma is the likely cause of the symptoms. An inhaled corticosteroid was prescribed and the symptoms resolved.

What have we learned?

The physical examination and routine PFTs are commonly normal in mild asthmatics. Methacholine challenge may be necessary for diagnosis.

Bronchitis is almost always viral in origin and persistent symptoms are often a sign of airway responsiveness. A therapeutic trial of inhaled corticosteroids is more often warranted than a trial of antibiotics.

Case 3

A 50-year-old woman has had known interstitial disease on CXR for 18 years. She had a pneumothorax on presentation at 32-years-old and had an open lung biopsy performed. The histological diagnosis on a lung biopsy was

Langerhans cell histiocytosis. CXR showed upper lobe nodular disease and some areas with cystic changes. Spirometry was obstructive with an FEV_1/FVC of 59% and an FEV_1 of 1.67 L (65% predicted). The total lung capacity was 90% of the predicted value. Diffusing capacity was 56% of the predicted value.

An exercise test was performed and the patient stopped exercising at 50% of the predicted maximal exercise capacity. At this time, the minute ventilation (the volume of air expired every minute) was 63% of the predicted maximal ventilation. This is determined from the formula:

Maximal ventilation = FEV_1 x 35

Normal subjects usually stop when ventilation reaches 70% to 80% of the predicted maximal ventilation. However, the heart rate reached 175 bpm, around 97% of the predicted maximal heart rate.

What have we learned?

The interpretation of the findings is that the patient was limited in her exercise performance by CV factors rather than ventilatory factors. The fast heart rate is indicative of a small stroke volume since the cardiac output increases in proportion to need. The interstitial lung disease is complicated by pulmonary hypertension which is a common accompaniment of such diseases. Dx

Take-home message

- Serial simple spirometry is very valuable in screening for significant respiratory disease and in managing asthma
- PFTs are underused
- COPD and asthma are often delayed in diagnosis
- Physical exam is insensitive in diagnosis of respiratory disease

Resources
1. Petty TL: John Hutchinson's Mysterious Machine Revisited. Chest 2002; 121(5 Suppl):219S-223S.
2. West JB: Challenges In Teaching The Mechanics Of Breathing To Medical And Graduate Students. Adv Physiol Educ 2008; 32(3):177-84.