

An Overview of Pulmonary Function Tests

stephenproctor.com

General

Pulmonary function testing primarily detects two abnormal patterns:

- **obstructive ventilatory defects** (such as asthma and COPD) and
- **restrictive ventilatory defects** (such as interstitial fibrosis and chest wall deformities).

Unlike some tests, pulmonary function testing is highly dependent on the efforts of the patient and the technician performing the test. Pulmonary function testing can be considered to be several tests in one.

What Is Normal?

The primary factors that determine what is normal for a given pulmonary function measurement are **Age, Height** and **Gender**. Weight is occasionally factored in, although wide variations in weight make little difference in the predicted normal value.

Various researchers have measured large groups of people to determine what is normal. The sets of normal values most commonly used are:

- **Knudson**
- **Crapo**
- **Morris/Polgar**

I use Knudson because it seems to be the most commonly used set of normal values. Our local hospital uses Morris/Polgar, although no one can tell me why. A study by Frymyer from Presbyterian Hospital of Dallas found at <http://www.allegiance.net/respiratory/ab2002/OF%202002%20Group%2013/OF-02-117.html> notes "For spirometry, Knudson was used by 72% of the hospitals, Crapo 17%, Morris, Collins, ITS and Enright (CHS) were used by 6% of the hospitals. For DLCO, Knudson was used by 44% of the hospitals, Crapo 28%, Miller 11%, Morris, Collins, Burrows, and Polgar were used by 6% of the hospitals."

In general, if a given pulmonary function measurement is within 80% and 120% of the predicted value, it is considered to be in the normal range. This is a huge "point spread," but it is the best we can do. For example, if an individual performs at 120% at age 20 and 80% at age 30, he or she is considered "normal" in both cases, yet has experienced a significant decrease in pulmonary function.

Spirometry/Flow Volume Loop

The patient takes a full breath in and blows out as long, hard and completely as possible. He or she then takes a full breath in before resuming normal breathing. This maneuver is done at least three times to be sure the results are **acceptable** and **reproducible**.

Several numbers are generated including the **FEV1** (the amount of air exhaled in one second) and the **FVC** (the total amount of air one can take into his or her lungs). The entire maneuver is usually repeated after a medication called a bronchodilator (albuterol) is given to open the breathing passages.

I tend to use the term "Spirometry" and the Sensormedics literature tends to use the term "Flow Volume Loop" to describe this test. In truth, they are different representations of the same information - "spirometry" referring to the numbers produced and "flow volume loop" meaning a graph produced by those numbers.

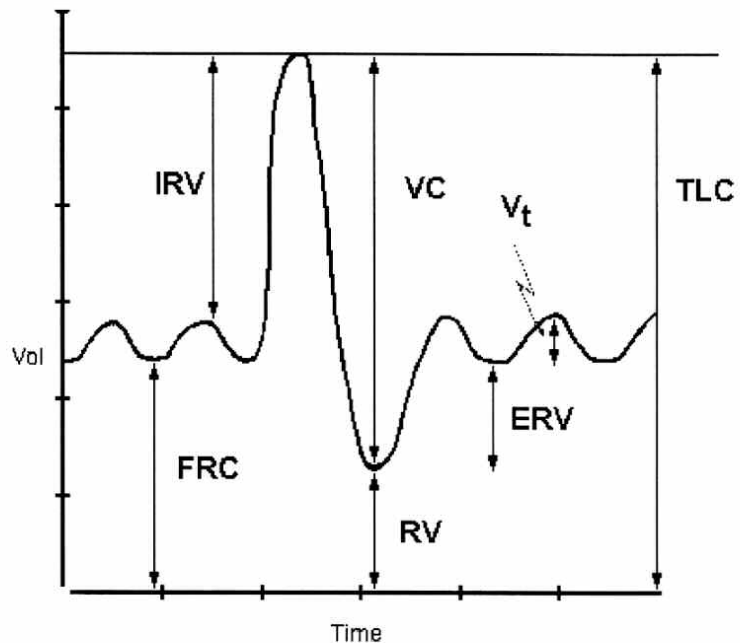
Maximum Voluntary Ventilation

This is often included under the above category, but it is a separate test. The patient breathes as much air as possible in and out for a given amount of time. It is possibly the least useful of these tests, although it can detect nervous system disorders.

Lung Volumes

The air that the lungs can hold can be divided into smaller compartments called "volumes." "Capacities" are combinations of two or more volumes. Since you will encounter these terms, I will discuss the important ones.

The amount of air a person breathes in and out during quiet, normal breathing is called the **Tidal Volume** (V_t). Notice that during such breathing, a person could breathe more in or blow more out.



The additional amount a person could inhale is called the **Inspiratory Reserve Volume** (IRV). The additional amount a person could exhale is called the **Expiratory Reserve Volume** (ERV). After a person blows out all the air he or she can, there is still some air in the lungs. This is called the **Residual Volume** (RV).

The **Total Lung Capacity** (TLC) is exactly what you would think - the total amount of air the lungs can contain. The **Vital Capacity** (VC) is the total amount of air the person can breathe in and out. The **Functional Residual Capacity** (FRC) is the total amount of air left in the lungs at the end of a normal exhalation.

If you prefer mathematical terms, get some help. No, really here are the relationships:

- $TLC = RV + ERV + V_t + IRV.$
- $VC = ERV + V_t + IRV.$
- $FRC = RV + ERV.$

Diffusion Studies

Diffusion studies measure the ability of a gas to go from the air sacs of the lungs into the blood stream. These studies do not really help differentiate an obstructive ventilatory defect from a restrictive ventilatory defect. Instead, these studies give a clue as to what disease process within that category is present.

Pulse Oximetry

This is not usually considered a pulmonary function test. It measures the amount of oxygen in small blood vessels called capillaries. Since the lungs' job is to provide oxygen to the body, pulse oximetry is the ultimate test of pulmonary function!

Interpreting The Test

In general, this is my approach to interpreting a pulmonary function test: First, I look at the **FEV1/FVC** ratio. If this is below 75%, an obstructive ventilatory defect is present. If the ratio is above 75%, are the **FVC** and **FEV1** low? If so, a restrictive ventilatory defect is likely and I next look at the lung volume section.

A low **Vital Capacity** confirms a restrictive ventilatory defect. Some regard the **Total Lung Capacity** as confirmatory, so I consider both. In general, in a restrictive ventilatory defect, the majority of lung volumes will be decreased. In an obstructive ventilatory defect is present, the **Residual Volume** will be high.

I also look at the shape of the flow volume loop to differentiate an obstructive ventilatory defect from a restrictive ventilatory defect. An obstructive ventilatory defect gives a distinctive pattern. A restrictive ventilatory defect looks like a normal flow volume loop, except that it is smaller.

As far as diffusion studies, a low **DLCO** can be seen in both emphysema and interstitial fibrosis. The **DLCO** can help differentiate the cause of a restrictive or obstructive ventilatory defect. In a restrictive ventilatory defect, interstitial fibrosis may cause a decrease in **DLCO** but chest wall deformities and obesity would not. In an obstructive ventilatory defect, emphysema may cause a decrease in **DLCO** but asthma would not. The **DLCO/VA** is an attempt to correct the diffusion for the actual lung volume being tested. A normal value should imply that the cause of the restriction is extrinsic to the lungs (such as a chest wall deformity or obesity) instead of intrinsic to the lungs (emphysema and interstitial fibrosis). However, a normal value can occur in any of these conditions.

This page was created as aid to my employees when we started doing pulmonary function testing in July of 1998. If this is helpful, feel free to use it.

