Understanding Pulmonary Function Testing

PFTs, BLOOD GASES, AND OXIMETRY

INTRODUCTION

This brochure is intended to help you understand the meaning of Pulmonary Function Testing, commonly referred to as PFTs. The information found on these pages is not meant to provide specific medical advice, or to replace the continuing care, guidance, and supervision provided by your physician and other members of your health care team. You should always seek proper medical advice and maintain regular communication with your physician. Many tests and measurements can be used to gain information about your lung health, including:

- Medical history
- Physical examination
- Chest CT and X-rays
- Arterial blood gases and oximetry
- PFTs
- Sputum culture
- Blood tests
- Bronchoscopy

While all of these tools are important in assessing your lung health, PFTs deserve special attention. That's because although PFTs are among the most familiar of all the lung tests, they are also some of the most difficult tests to understand. PFTs are a series of different breathing tests performed under the guidance of a trained pulmonary function technician, physician, or nurse and are typically done in a hospital or clinic setting. There are a variety of specific pulmonary function tests that may be ordered by your physician. Most of these breathing tests are done by blowing into a tube while sitting in a chair.

While there are many tests and tools for looking at lung health, pulmonary function tests (PFTs) deserve special attention. That's because many Alphas report that PFTs are hard to understand.

WHAT ARE PULMONARY FUNCTION TESTS?

PFTs are breathing tests that involve blowing into a tube. You do them at a hospital or clinic, under the guidance of a trained pulmonary function technician, doctor, or nurse.

PFTs are helpful for:

- Preparing for lung surgery
- Measuring effects of treatment
- Figuring out how badly your airways or other lung tissue have been affected by Alpha-1

Your doctor will repeat PFTs as often as they think is necessary. They rarely make medical diagnoses from PFTs alone. But periodic tests help them monitor lung problems or abnormalities.

KEY LEARNING: Before your appointment you may receive specific instructions about how to prepare for the test. Pay particular attention to medications you should or should not use before the test.

How should you prepare for pulmonary function tests?

- Wear loose clothing that doesn't restrict your breathing.
- Avoid large meals before your test. This may make it more comfortable to breathe deeply.

NOTE: When you make your PFT appointment, ask if you should use your inhalers before your test.

What will happen during the test?

Pulmonary function testing includes a number of different tests. The person coaching you through your testing will give you instructions before each test. If you don't understand, ask questions! For the best results, listen carefully and follow the coaching. If you feel tired, ask for time to rest.

Are pulmonary function tests safe?

Some people are concerned about the cleanliness of PFT equipment. You may feel better knowing staff clean and disinfect the equipment between patients. Also, the equipment has filters that catch more particles than the N-95 masks we use for COVID protection.

What do the results mean?

A doctor will interpret the results of your PFTs by comparing them to predicted normal values for someone your age, size, race, and sex. These values are based on research studies of non-smoking people with healthy lungs.

What words will your doctor use?

When your doctor talks about your results, they will use terms such as mild, moderate or severe. They will also use obstructive and restrictive to describe airflow and lung volume. They may also mention names of specific diseases like emphysema, chronic obstructive pulmonary disease (COPD), or bronchitis.

What if my PFT results are bad?

Your test results don't determine your quality of life. Many people with limited lung function live fulfilling lives!

There are many ways to keep or improve your quality of life. You can try pulmonary rehabilitation to improve your lung function and reduce your symptoms. You can join a support group and share your struggles with people who understand them.

Talk to your doctor to see what you can do. Your options might surprise you.

SPIROMETRY

Spirometry is the simplest and most common pulmonary function test. Here's how you do the test:

1. Put on a nose clip, so air can't escape through your nose.
2. Wrap your mouth around the mouthpiece of the spirometer.
3. Breathe in as deeply as you can.
4. Blast your breath out as long and as hard as you can.
5. Repeat steps 1–4 three times or more.

NOTE: Your doctor may tell you not to do your usual breathing treatments on the day of your test. But they may ask you to take a bronchodilator before the test. A bronchodilator is an inhaled medicine that may open up your airways. Some PFT labs routinely test before and after you take a bronchodilator medicine. Others will test on your current medicines.

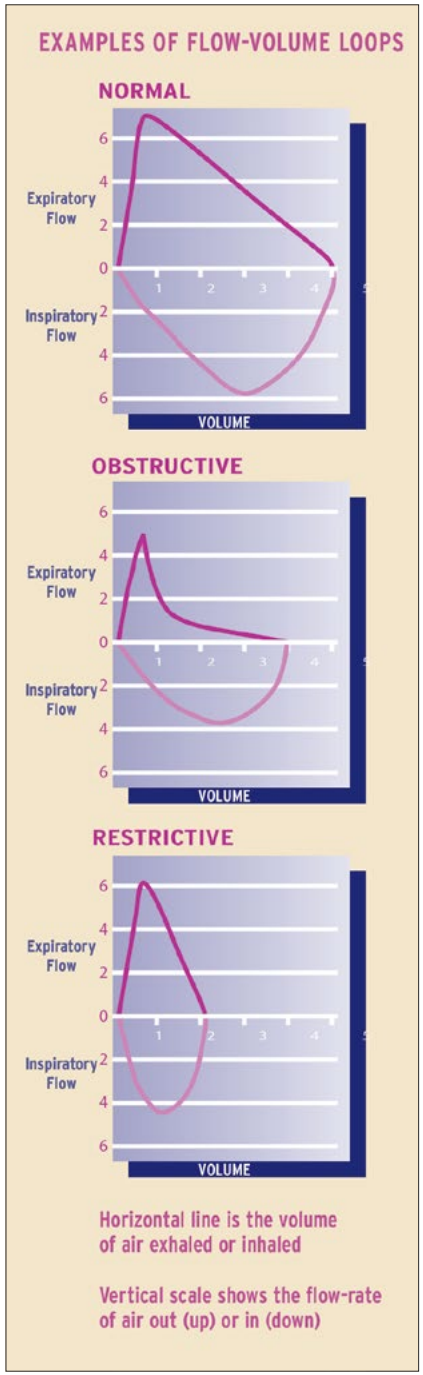
Your body's response to the bronchodilator tells your doctor what kind (and how much) airway disease you may have. If your spirometry improves after a breathing treatment, this implies that your airways may respond the same way in the future.

What spirometry measures

The spirometer (spirometry-testing machine) measures both the amount of air you exhaled and the time it takes you to exhale it.

Here are some common spirometry measurements:

Forced Vital Capacity (FVC) is the total volume of air you exhale during the test. With the help of a computer, your FVC



effort may be used to create a line drawing called a "flow volume curve" or "flow-volume loop." (See chart entitled "Examples of Flow-Volume Loops.")

Forced Expiratory Volume in the First Second (FEV1) is the volume of air that you can forcefully blow out during the first second of the FVC. Lower than normal FEV1 may be a sign of reduced flow rates caused by chronic obstructive pulmonary diseases (COPD) emphysema, asthma, or chronic bronchitis.

Ratio of FEV1 to FVC (FEV1/FVC) is what you get when you divide your actual FEV1 by your actual FVC. It's usually stated as a percentage. In a normal adult, the ratio ranges from 70 to 85%, but decreases with age. Your FEV1/FVC ratio helps show what kind of lung disease or damage you might have.

Peak Expiratory Flow or Peak Flow (PEF OR PF) is the fastest flow rate reached at any time during the FVC. It normally occurs near the beginning of your forced breath out. PEF may be reported as Forced Expiratory Flow Maximum (FEF Max).

LUNG VOLUMES TESTING

To find out more about your lung health, your doctor may order lung volumes as part of your pulmonary function testing. Lung volumes testing measures eight separate volumes of air:

Total Lung Capacity (TLC) is the maximum amount of air that your lungs can hold. This is measured at the very top of an inhalation.

Vital Capacity (VC) or Slow Vital Capacity (SVC) is the maximum amount of air you can exhale during a normal or slow exhalation after you have filled your lungs.

Functional Residual Capacity (FRC) is the amount of air left in the lungs after you exhale normally.

Residual Volume (RV) is the air remaining in the lungs after you exhale as much air as possible.

Tidal Volume (VT) is the amount of air that you inhale and exhale with each normal breath. TV is the same as normal breathing when you are at rest.

Inspiratory Reserve Volume (IRV) is the greatest amount of extra air you can inhale after inhaling normally.

Inspiratory Capacity (IC) is the maximum amount of air you can inhale after exhaling a normal breath.

Expiratory Reserve Volume (ERV) is the greatest amount of extra air you can exhale after a normal exhalation.

What do your lung volume test results tell us?

Obstructive lung diseases usually show:

- Increased TLC
- Increased RV
- Normal or decreased VC

Restrictive lung diseases may show decreased levels of TLC, RV, and VC.

How do we measure lung volumes?

The three most common methods for measuring lung volumes are:

1. **Nitrogen Washout** – done by breathing in pure oxygen and measuring the amount of nitrogen in your exhaled gas.
2. **Helium Dilution** – done by breathing a mixture of helium and oxygen.
3. **Body Box (plethysmography)** – done by taking a series of very small panting breaths while sitting in an enclosed clear chamber. This is the most accurate lung volume measurement technique.

DIFFUSING CAPACITY (DLCO)

Pulmonary Function Testing (PFT) may include a diffusing capacity (DLCO) test. This test measures how well gases like oxygen move from your lungs into your blood.

CROSS REFERENCE: The BFRG has a video that explains gas exchange. Just search for ***Your Body and Lung Disease***.

How do we measure diffusing capacity?

There are several ways to measure diffusing capacity. The "ten-second single breath-hold technique" is the most common. It's an easy, five-step test:

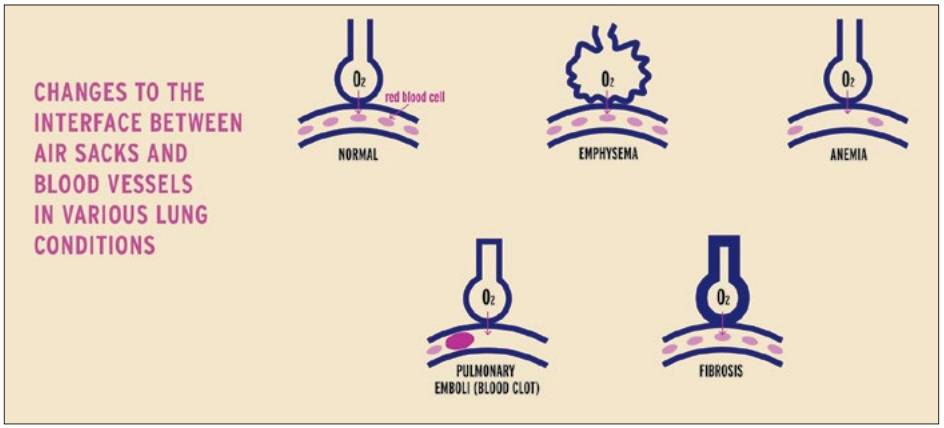
1. Put on a nose clip, so air can't escape through your nose.
2. Put the mouthpiece into your mouth.
3. Breathe in deeply.
4. Hold your breath for at least 10 seconds.
5. Exhale.

How it works

When you inhale through the mouthpiece, you're breathing in a test mixture of gases. When you exhale, the machine takes a sample of the gases you breathe out.

What your results mean

Carbon dioxide and oxygen are exchanged in your alveoli. These are tiny air sacs in your lungs. The diffusing capacity test tells your doctor whether your alveoli have been damaged. (See infographic entitled "Changes to the Interface between Air Sacks and Blood Vessels in Various Lung Conditions.")



What factors affect your Diffusion Capacity (DLCO)?

Three major factors that determine diffusion capacity:

1. The amount of lung tissue that comes in contact with blood vessels. This is called the lung blood interface.
2. The thickness of the wall of the lung air sac. (The thicker the wall, the lower the diffusing capacity.)
3. The pressure difference between the gas in the air sacs and the gas in your blood.

Some disease conditions may cause a lower than normal DLCO:

1. These conditions decrease the area for diffusion:
   - Pulmonary emphysema
   - Lung lobe removal
   - Lung tumor
   - Anemia
   - Pulmonary emboli (blood clot)

2. These conditions increase the thickness of the air sac wall:
   - Pulmonary Fibrosis
   - Farmer's lung
   - Asbestosis
   - Congestive heart failure

NOTE: You'll find many of these conditions listed at the end of this guide in the Glossary of Pulmonary Function Terms.

ARTERIAL BLOOD GASES AND PULSE OXIMETRY

Testing levels of arterial blood gases (ABGs) gives your doctor important information about your lung health. ABG tests show how well your lungs take in oxygen from your blood and get carbon dioxide out.

How do we measure arterial blood gases?

Your doctor will take blood from one of your arteries, usually near your wrist. They send the blood to a lab to measure its blood gases. The most important measurements in your blood gas sample are:

- Acid–base balance (pH)
- Carbon dioxide (PaCO2)
- Oxygen (PaO2)
- Oxygen saturation (SaO2)

What do those measurements mean?

pH: This is your body's acid–base balance. Although body fluids are mainly water, they do contain a mixture of acids and bases. If your blood pH is below 7.35, you have too much acid (acidosis). If your pH is above 7.45, you have too much base (alkalosis).

To function properly, your body needs a balanced pH. Lung disease or problems in other organs can cause too much acid or base in your arterial blood.

PaCO2: This is the amount of carbon dioxide in your arterial blood. We measure PaCO2 in units called "millimeters of mercury" (mm Hg). CO2 buildup in your blood is often a sign of severe lung disease.

PaO2: This is the actual amount of oxygen in your arterial blood. We also measure PaO2 in millimeters of mercury (mmHg). This value decreases somewhat as we get older. A low PaO2 may mean abnormal lung function.

SaO2: This is the percentage of hemoglobin molecules in your blood that are carrying oxygen. For example, 80% or 95%.

BURNING ISSUE: At high altitudes, oxygen and saturation levels may decrease. During airline flights, these levels may also be affected.

Pulse Oximetry

A pulse oximeter is a device that estimates the saturation of oxygen in your blood (SaO2). It's not as accurate as an arterial blood gas saturation. So, it's best used as a guide for oxygen levels. Normal values range from 93–100%.

Most pulse oximeters clip onto your finger, but some may be attached to an ear lobe.

WHAT DO PFTS MEAN FOR YOU?

Keep in mind quality of life is not determined by the results of your tests. Each person is unique, and many people live fulfilling lives with limited lung function. The key is to explore ways to keep or improve your quality of life.

Methods used to accomplish this may include:

- Exercise
- Breathing techniques
- Proper medications
- Equipment aids
- Social and emotional support

Pulmonary Rehabilitation programs and support groups are valuable sources of information. There is an excellent video on Pulmonary Rehabilitation in the Big Fat Reference Guide. Develop a partnership with your physician. Good communication is essential, so don't be afraid to ask questions.

CROSS REFERENCE: A comprehensive guide to help you manage Alpha-1 Antitrypsin Deficiency can be found in the ***Big Fat Reference Guide***.

GLOSSARY OF PULMONARY FUNCTION TERMS

If you're talking to your doctor about pulmonary function testing, it helps to know key terms. This glossary contains some common words your doctor may use when talking about lung disease and tests for lung function.

Alpha-1 Antitrypsin Deficiency – A genetic condition that can affect all age groups. It may lead to emphysema at an early age (30-40 years old).

Alveoli or Air Sacs – Microscopic grape-like structures in the airways of your lungs. Gas exchange takes place in these air sacs.

American Thoracic Society (ATS) – Society of doctors and other healthcare workers who work to advance the science of lung health. ATS sets standards for testing pulmonary (lung) function.

Anemia – When you don't have enough red blood cells and hemoglobin (a protein that carries oxygen) in your blood.

Arterial Blood Gases (ABGS) – Sample of blood drawn from an artery, most often near the wrist. This measures acid-base balance (pH), carbon dioxide (PaCO2), oxygen (PaO2), and oxygen saturation (SaO2).

Asbestosis -Lung disease that can develop after inhaling asbestos fibers. It may cause scar tissue to surround the lungs.

Bronchodilator – Medicine that dilates or opens up the airways in your lungs. You may get it from a nebulizer, inhaler, or oral pill.

Carbon Dioxide (PaCO2) – Amount of carbon dioxide in your arterial blood. Carbon dioxide is a normal by-product of the body. You exhale it from your body when you breathe.

Congestive Heart Failure (CHF) – Excessive fluid buildup in the body due to heart weakness. It can make you feel like you're out of breath.

Emphysema – Airway disease in which the walls of the alveoli (air sacs) are damaged or destroyed.

Farmer's Lung – Lung disease caused by breathing in wet hay or molds.

Flow Volume Curve or Loop – Graph plotting the flow (speed) and volume at which you breathe in and out during the FVC test.

Obstructive Lung Disease/COPD – Chronic disease that makes it hard to exhale or breathe out. These include emphysema, chronic bronchitis, and asthma.

Oxygen (PaO2) – Amount of oxygen in your arterial blood.

Oxygen Saturation (SaO2) – Percent of hemoglobin in red blood cells carrying oxygen.

Pulmonary – Anything that involves your lungs.

Pulmonary Fibrosis – Lung disease caused by scar tissue in the lungs.

Red Blood Cell (RBC) – Blood cell that contains hemoglobin. RBCs carry oxygen in your blood.

Restrictive Lung Disease – Disease that makes it hard to inhale, or breathe in. These include asbestosis, farmer's lung, and fibrosis.

NOTES

AlphaNet

Thank you to our sponsors:

GRIFOLS

CSL Behring
Biotherapies for Life™

Takeda

This single topic brochure is one of a series extracted from AlphaNet's Big Fat Reference Guide to Alpha-1 (the BFRG), which is available on the AlphaNet website (www.alphanet.org).

To find the AlphaNet Coordinator nearest you, visit our website at www.alphanet.org.