Contents

Pulmonary Function Testing

Guidelines

Spirometry

ATS/ERS 2019 : Standardization of Spirometry 2019 Update.

B. L. Graham et al- American Journal of Respiratory and Critical Care Medicine 2019; 200(8): e70–e88

Spirometry is the most common pulmonary function test. It is widely used in the assessment of lung function to provide objective information used in the diagnosis of lung diseases and monitoring lung health. Revisions to the 2005 technical standards for spirometry were made by an international joint task force, appointed by the American Thoracic Society and the European Respiratory Society, addressing improvements in instrumentation and computational capabilities, together with new research studies and enhanced quality assurance approaches.

ATS/ERS 2005 : Standardisation of Lung Function Testing: Standardisation of the measurement of spirometry.

V. Brusasco, R.Crapo and G. Viegi - Eur Respir J 2005; 26: 319–338

Spirometry is a physiological test that measures how an individual inhales or exhales volumes of air as a function of time. The primary signal measured in spirometry may be volume or flow. Spirometry is invaluable as a screening test of general respiratory health in the same way that blood pressure provides important information about general cardiovascular health. In this document, the most important aspects of spirometry are the forced vital capacity (FVC), which is the volume delivered during an expiration made as forcefully and completely as possible starting from full inspiration, and the forced expiratory volume (FEV) in one second, which is the volume delivered in the first second of an FVC manoeuvre. Other spirometric variables derived from the FVC manoeuvre are also addressed.

ERS TASK FORCE Global Lung Initiative 2012: Multi-ethnic reference values for spirometry for the 3-95-yr age range: the global lung function 2012 equations

Quanjer PH et al "" - Eur Respir J. 2012 Dec;40(6):1324-43.

This study has led to the derivation of continuous equations for predicted values and age-appropriate LLN for spirometric indices from 3–95 yrs of age, based on 74,187 records from healthy nonsmoking males and females from 26 countries across five continents. Ethnic and geographic groups can be grouped under the headings Caucasian, African–American, and North and South East Asian. The GLI 2012 reference equations are a huge step forward, providing a robust reference standard to streamline the interpretation of spirometry results within and between populations worldwide.

Broncho Challenge

ERS technical standard on bronchial challenge testing: general considerations and performance of methacholine challenge tests.

Coates AL, Wanger J, Cockcroft DW, Culver BH; and the Bronchoprovocation Testing Task Force. Eur Respir J. 2017 May 1;49(5)

This international task force report updates general considerations for bronchial challenge testing and the performance of the methacholine challenge test. There are notable changes from prior recommendations in order to accommodate newer delivery devices.

COSMED Homepage

http://www.cosmed.com

COSMED Resources

https://www.cosmed.com/resources

COSMED
The Metabolic Company

ATS 1999: Guidelines for Methacholine and Exercise Challenge Testing.

Crapo RO et al. - Am J Respir Crit Care Med Vol 161, Pp 309-329, 2000

This statement provides practical guidelines and suggestions for methacholine and exercise challenging testing. Specifically, it reviews indications for these challenges, details factors that influence the results, presents brief step-by-step protocols, outlines safety measures, describes proper patient preparation and procedures, provides an algorithm for calculating results, and offers guidelines for clinical interpretation of results. The details are important because methacholine and exercise challenge tests are, in effect, dose–response tests and delivery of the dose and measurement of the response must be accurate if a valid test is to be obtained. These guidelines are geared to patients who can perform good-quality spirometry tests; they are not appropriate for infants or preschool children.

Body Plethysmography (TGV,RAW)

ATS/ERS 2005: Standardisation of Lung Function Testing: Standardisation of the measurement of lung volumes.

V. Brusasco, R. Crapo and G. Viegi - Eur Respir J 2005; 26: 511-522

The determination of FRC is the key component in the measurement of lung volumes, and can be assessed by body plethysmography, gas washout or gas dilution methods, or using radiography. The FRCpleth includes nonventilated, as well as ventilated, lung compartments, and, thus, yields higher results than the gas dilution or washout methods. The FRCpleth may be further increased by gas that is present in the abdomen. In cases of severe airflow obstruction, FRCpleth may be overestimated when panting rates are >1 Hz.

ERS 1997: Measurement of lung volumes by plethysmography.

Coates AL, Peslin R, Rodenstein D, Stocks J. - Eur Respir J. 1997 Jun;10(6):1415-27

Review of the principles, practice and limitations of plethysmography, and recommend standards for the plethysmographic measure of lung volumes. These standards will include equipment specifications and measurement techniques over the age range from infancy to adulthood.

Difusing Lung Capacity

2017 ERS/ATS standards for single-breath carbon monoxide uptake in the lung.

Graham BL, Brusasco V, Burgos F, Cooper BG, Jensen R, Kendrick A, MacIntyre NR, Thompson BR, Wanger J. Eur Respir J. 2017 Jan 3;49(1)

A joint taskforce appointed by the ERS and ATS reviewed the recent literature on the measurement of DLCO and surveyed the current technical capabilities of instrumentation being manufactured around the world. The recommendations in this document represent the consensus of the taskforce members in regard to the evidence available for various aspects of DLCO measurement.

ATS/ERS 2005: Standardisation of Lung Function Testing: Standardisation of the single breath determination of carbon monoxide uptake in the lung.

V. Brusasco, R.Crapo and G. Viegi - Eur Respir J 2005; 26: 720-735

The single-breath determination of DL,CO involves measuring the uptake of CO from the lung over a breathholding period. While it is recommended that at least two DL,CO tests should be performed, research is needed to determine the actual number of tests required to provide a reasonable estimate of average DL,CO value for a given person.

Implementing the three –equation method of measuring single breath carbon monoxide diffusing capacity.

Graham BL, Mink JT, Cotton DJ - Can Respir J 1996; 3 (4): 247-257

Measurements of DLcoSB using the three-equation method can potentially improve both the precision and the accuracy of DLcoSB while permitting the measurement to be made from a single breath manoeuvre, which can be done eqully well by normal subjects and by patients with lung disease and which far more closely resembles normal respiration.

ATS 1995: Single-breath carbon monoxide diffusing capacity (transfer factor). Recommendations for a standard technique--1995 update.

American Thoracic Society. Am J Respir Crit Care Med. 1995 Dec;152(6 Pt 1):2185-98

Measuring an "overall" CO uptake by the single-breath technique has proved useful in assessing a variety of lung abnormalities that impair alveolar capillary gas transport. Moreover, in many diseases, the magnitude of abnormalities in DLCO has been shown to correlate with disease severity and with direct measurements of arterial blood oxygenation, especially during exercise.

ERS 1993: Standardization of the measurement of transfer factor (diffusing capacity). Official Statement of the European Respiratory Society.

Cotes JE, Chinn DJ, Quanjer PH, Roca J, Yernault JC. Eur Respir J Suppl. 1993 Mar;16:41-52

The measurement of transfer factor (TL) usually constitutes the second stage in the assessment of lung function after the performance of spirometry and measurement of lung volume. The transfer factor is used mainly for the diagnosis and clinical management of persons with suspected or confirmed disease of the parenchyma of the lung, for example generalised emphysema, interstitial fibrosis or extrinsic allergic alveolitis.

Nitrogen Washout (FRC)

ATS/ERS 2013: Consensus statement for inert gas washout measurement using multiple and single breath tests.

Robinson PD, Latzin P, Verbanck S, Hall GL, Horsley A, Gappa M, Thamrin C, Arets HG, Aurora P, Fuchs SI, King GG, Lum S, Macleod K, Paiva M, Pillow JJ, Ranganathan S, Ratjen F, Singer F, Sonnappa S, Stocks J, Subbarao P, Thompson BR, Gustafsson PM - Eur Respir J 2013; 41: 507–522

Marked ventilation distribution abnormalities occur in obstructive lung disease despite normal ventilatory capacity as measured by spirometry. Washout tests may provide insight into mechanisms behind abnormal ventilation distribution and localisation of pathology. MBW is particularly attractive as it uses either relaxed tidal breathing (mostly in paediatric settings) or a fixed tidal volume (usually 1 L in adults) without need for maximal effort, thereby offering feasibility in all age groups. Washout recording systems determine inspired and expired inert gas volumes, by continuously measuring inert gas concentrations synchronised with respiratory flow.

ATS/ERS 2005: Standardisation of Lung Function Testing: Standardisation of the measurement of lung volumes.

V. Brusasco, R. Crapo and G. Viegi - Eur Respir J 2005; 26: 511-522

The gas dilution/washout methods are widely used because they are simple to perform and the instrumentation is relatively inexpensive.

If measurements of N2 concentration are made indirectly by subtracting measurements of O2 and CO2, the accuracy, drift and linearity characteristics of the O2 and CO2 analysers should result in indirect calculations of N2, with comparable performance characteristics to the direct measurements of N2 specified previously.

ATS/ERS 1997: Multiple-breath nitrogen washout techniques: including measurements with patients on ventilators.

Newth CJ, Enright P, Johnson RL - Eur Respir J. 1997 Sep;10(9):2174-85

If the primary interest is alveolar growth and development, or the assessment of total gas volume in a child with airway disease, then plethysmography may be the most relevant technique. By contrast, if one is interested in the accessible, rather than compressible lung volume, i.e. the functional lung volume available for gas exchange, then one of the gas dilution techniques may be more appropriate.

Under certain circumstances, it may also be rational to use both techniques, depending on the clinical entity that is to be measured. For example, in lung cysts and lobar emphysema, use of both FRC measured in an infant plethysmograph (FRCpleth) and a gas dilution technique will allow quantification of the amount of gas trapped.

Except in the smallest of infants, sedation is required for each technique up to the age of 4–6 yrs.

The open circuit, multiple-breath nitrogen washout test used to measure lung volumes should not be confused with the single-breath nitrogen test, also known as the "closing volume" test. Both tests use similar instrumentation, both can give measurements of FRC and the degree of nonuniformity of gas distribution in the lungs, but the multiple-breath test more accurately measures absolute lung volumes.

Forced Oscillations Technique (FOT)

ERS 2020: Technical standards for respiratory oscillometry.

G. G. King, J. Bates, K. I. Berger et al - Eur Respir J 2020; 55

Oscillometry (also known as the forced oscillation technique) measures the mechanical properties of the respiratory system (upper and intrathoracic airways, lung tissue and chest wall) during quiet tidal breathing, by the application of an oscillating pressure signal (input or forcing signal), most commonly at the mouth. An ERS task force of experts active in clinical oscillometry, has produced an update of the 2003 ERS technical standards, addressing all technical details of the hardware design, signal processing and analyses and testing protocols. The main changes refer to new quality control procedures and artefacts handling, reporting, threshold values for bronchodilator and bronchial challenge tests and updates on preedicted impedance values in adults and children.

ATS/ERS 2007: An Official American Thoracic Society/European Respiratory Society Statement: Pulmonary Function Testing in Preschool Children.

Nicole Beydon , et al - Am J Respir Crit Care Med Vol 175. pp 1304–1345, 2007

The FOT is a simple, noninvasive technique performed during tidal breathing that is relatively easy to apply in preschool children. An external pressure wave is applied, usually at the mouth, and the resulting pressure–flow relationship is analyzed in terms of respiratory impedance. The latter expresses the impediment to flow in the respiratory system that includes both frictional losses and elastic and inertial loads. The FOT has been successfully performed in settings ranging from the field study to the emergency room. A number of studies have demonstrated that the FOT was able to identify airway obstruction and responses to bronchodilators and bronchoconstrictors.

ERS 2003: The FOT in clinical practice. Methodology, recommendations and future developments

Oostveen E, MacLeod D, Lorino H, Farré R, Hantos Z, Desager K, Marchal F - Eur Respir J 2003; 22: 1026–1041

The forced oscillation technique (FOT) is a noninvasive method with which to measure respiratory mechanics. FOT employs small-amplitude pressure oscillations superimposed on the normal breathing and therefore has the advantage over conventional lung function techniques that it does not require the performance of respiratory manoeuvres. FOT data, especially those measured at the lower frequencies, are sensitive to airway obstruction, but do not discriminate between obstructive and restrictive lung disorders. Forced oscillation technique is a reliable method in the assessment of bronchial hyperresponsiveness in adults and children. Moreover, in contrast with spirometry where a deep inspiration is needed, forced oscillation technique does not modify the airway smooth muscle tone. Forced oscillation technique has been shown to be as sensitive as spirometry in detecting impairments of lung function due to smoking or exposure to occupational hazards. Together with the minimal requirement for the subject's cooperation, this makes forced oscillation technique an ideal lung function test for epidemiological and field studies. Novel applications of forced oscillation technique in the clinical setting include the monitoring of respiratory mechanics during mechanical ventilation and sleep.

Respiratory Mechanics

ATS/ERS 2002 : Statement on Respiratory Muscle Testing.

Am J Respir Crit Care Med 2002, 166:518-624

The principal advantage of volitional tests is that they give an estimate of inspiratory or expiratory muscle strength, are simple to perform, and are well tolerated by patients. However, it can be difficult to ensure that the subject is making a truly maximal effort. Measurement of the maximum static inspiratory pressure that a subject can generate at the mouth (PI max) or the maximum static expiratory pressure (PE max) is a simple way to gauge inspiratory and expiratory muscle strength. The pressure measured during these maneuvers reflects the pressure developed by the respiratory muscles (Pmus).

Pulmonary Function Testing in Asthma

European Respiratory Society clinical practice guidelines for the diagnosis of asthma in children aged 5–16 years.

E. A. Gaillard, C. E. Kuehni, S. Turner et al - Eur Respir J. 2021.

Diagnosing asthma in children represents an important clinical challenge. There is no single gold standard test to confirm the diagnosis. Consequently, both over-, and under-diagnosis of asthma are frequent in children. A Task Force (TF) supported by the European Respiratory Society has developed these evidencebased clinical practice guidelines for the diagnosis of asthma in children aged 5 to 16 years using nine PICO (Population, Intervention, Comparator and Outcome) questions. The TF then developed a diagnostic algorithm based on the critical appraisal of the PICO questions, preferences expressed by lay members and test availability. Accordingly, the TF recommends spirometry, bronchodilator reversibility testing and FeNO as first line diagnostic tests in children under investigation for asthma.

GINA 2019: a fundamental change in asthma management.

H. K. Reddel, J. M. FitzGerald, E. D. Bateman et al - Eur Respir J. 2019, 53.

The GINA report, which is updated annually, comprises an integrated strategy focusing not only on evidence, but also on translation into clinical practice. Evidence is considered and recommendations are framed, not as discrete questions, but in the context of their relationship to the overall goals of treatment. The GINA strategy has a strong focus on preventing asthma-related deaths and severe exacerbations, as well as on efficacy and effectiveness for symptom control and lung function, and it promotes personalised treatment decisions across the spectrum of asthma severity.

Asthma: diagnosis, monitoring and chronic asthma management. NICE guideline.

NG80, Nov 2017

This guideline covers diagnosing, monitoring and managing asthma in adults, young people and children. It aims to improve the accuracy of diagnosis, help people to control their asthma and reduce the risk of asthma attacks. Objective test threshold levels are defined for fractional exhled nitric oxide (FeNO), spirometry, bronchodilator reversibility (BDR) testing, peak flow measurement and bronchial challenge tests with histamine or metacholine and algorithms for clinical assessment are described for adults, young people and children with suspected asthma.

Pulmonary Function Testing in COPD

Global strategy for the diagnosis, management and prevention of chronic obstructive pulmonary disease.

Global Initiative for Chronic Obstructive Lung Disease (GOLD), 2021.

The GOLD report is revised annually and has been used worldwide by healthcare professionals as a tool to implement effective management programs based on local healthcare systems. In the 2022 revision of the GOLD report new evidence and novel recommendations are discussed for many topics, including the use of DLCO measurement for COPD assessment, the reduction of lung function decline by pharmacological treatments and the association of high blood eosinophils with the incidence and progression of COPD.

An official ATS/ERS statement: research questions in chronic obstructive pulmonary disease.

B. R. Celli, M. Decramer, J. A. Wedzicha et al, Am J Respir Crit Care Med, 2015, 191(7):e4-e27.

The goal of this official ATS/ERS Research Statement is to describe evidence related to diagnosis, assessment, and management, identify gaps in knowledge and make recommendations for future research of chronic obstructive pulmonary disease (COPD). Pulmonary function tests are recommended as the reference standard to identify CT findings that are associated with clinically significant features and differential responses to treatment.

Diagnosis and management of stable chronic obstructive pulmonary disease: a clinical practice guideline update from the ACP, ACCP, ATS and ERS.

A. Qaseem, T. J. Wilt, S. E. Weinberger et al, Ann Intern Med, 2011, 155:179-191.

This guideline is an official statement of the ACP, ACCP, ATS and ERS. It represents an update of the 2007 ACP clinical practice guideline on diagnosis and management of stable chronic obstructive pulmonary disease (COPD) and is intended for clinicians who manage patients with COPD. This guideline addresses the value of history and physical examination for predicting airflow obstruction; the value of spirometry for screening or diagnosis of COPD; and COPD management strategies, specifically evaluation of various inhaled therapies.

Pulmonary Function Testing in COVID-19

International consensus on lung function testing during COVID-19 pandemic and beyond.

A. McGowan, P. Laveneziana, S. Bayat et al, Eur Respir J, 2021.

This document is an international expert consensus opinion incorporating considered published evidence since the onset of COVID-19 pandemic. Important factors for Lung Function Testing (LFT), considerations on transmission, subject, environment and equipment protection and test-specific procedures are addressed.

Medium-term impact of COVID-19 on pulmonary function, functional capacity and quality of life.

F. Anastasio, S. Barbuto, E. Scarnecchia et al, Eur Respir J, 2021.

The aim of this study is to evaluate the respiratory function 4 months after diagnosis in a large sample of patients surviving to SARS-COV-2 infection and the difference between patients with or without initial lung involvement Findings show impaired pulmonary function test parameters and 6MWT SpO2 values 4 months after the acuteness in patients with a worst lung involvement during SARS-COV-2 infection. Clinical and instrumental long-term check on these patients is advised, enabling a respiratory rehabilitation course aimed at respirational recovery.

Pulmonary function and COVID-19.

M. Thomas, O. J. Price, J. H. Hull, Current Opinion in Physiology, Jun 2021, 21.

The impact of COVID-19 infection on pulmonary function and its relation with disease severity and with the clinico-radiological outcomes are investigated. Encountered reductions in DLco and in TLC in patients following COVID-19 infection and the long-term impact that SAR-CoV-2 infection has on PFT, suggest the need to continue interrogating the factors limiting physical exercise performance and PFT.

Pulmonary Function Testing in Occupational Health

ACOEM guidance statement: spirometry in occupational health-2020.

M. C. Townsend, JOEM, 2020, 62(5):e208-e230.

The American College of Occupational and Environmental Medicine (ACOEM) developed three spirometry position statements prior to this document, which summarized advances of particular relevance to occupational health practice. This 2020 ACOEM guidance statement incorporates the latest spirometry testing changes into its recommendations to provide current information for all users of spirometry test results, from those who perform or supervise testing to those who only interpret or review results. Equipment performance, test execution, reference values, interpretation, evaluation of abnormalities and recordkeeping are addressed.

Official ATS technical standards: spirometry in the occupational setting.

C. A. Redlich, S. M. Tarlo, J. L. Hankinson et al, Am J Respir Crit Care Med, 2013, 189(8):984-994.

This document addresses aspects of the performance and interpretation of spirometry that are particularly important in the workplace, where inhalation exposures can affect lung function and cause or exacerbate lung diseases, such as asthma, chronic obstructive pulmonary disease, or fibrosis. Spirometry performed in the work setting should be part of a comprehensive workplace respiratory health program.

Pulmonary Function Testing in Pulmonary Hypertension

2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension.

N. Galiè, M. Humbert, J-L Vachiery et al - Eur Respir J. 2015, 46:903-975.

The European Society of Cardiology (ESC) and the European Respiratory Society (ERS) undertook a comprehensive review of the published evidence for management (including diagnosis, treatment, prevention and rehabilitation) of pulmonary hypertension. An algorithm for reaching a diagnosis is provided, and pulmonary function testing and arterial blood gases analysis are recommended for identifying the contribution of underlying airway or parenchymal lung disease.