

REPORT DOCUMENTATION PAGE

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Office Spirometry: ATS 2017 Update

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Disclosures

- None
- The opinions expressed in this presentation are solely those of the presenters and do not reflect the official views or policy of Department of Defense, or its Components

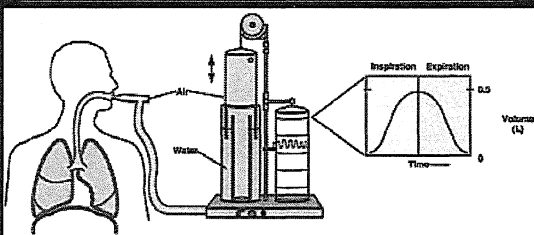
Learning Objectives

- Identify the source and relevance of the ATS/ERS guidelines for lung function testing and the ATS 2017 updated standard for reporting
- Review the ATS/ERS recommendations for correct performance of spirometry
- Recognize ATS/ERS guidelines to interpret and classify the severity of identified abnormalities

Overview

- Background
- Spirometry and ATS guidance
 - Performance of test
 - Data Gathered – new 2017
 - Interpretation
 - Assessment of normal – new 2017
 - Reference equations – new 2017
 - Determining acceptability – new 2017
 - Report Formatting – new 2017
 - Approach to evaluation
 - Severity classification

Instrumentation



<http://respiratorysystems.blogspot.com>



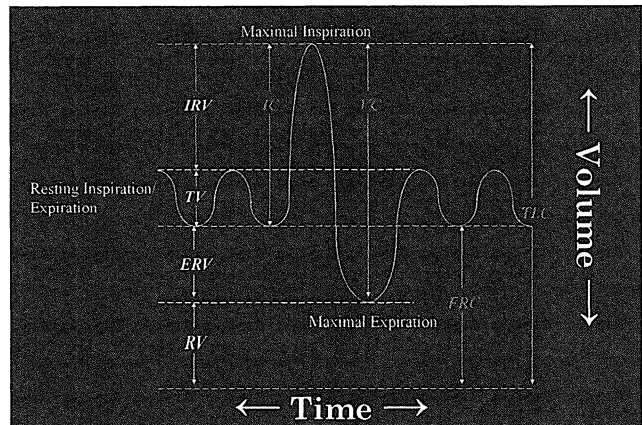
Instrumentation



<http://health.allnfor.com/pictures-images/spirometry.html>

Basic Definitions

- 4 Lung volumes - cannot be further subdivided
 - Tidal volume (TV)
 - Inspiratory reserve volume (IRV)
 - Expiratory reserve volume (ERV)
 - Residual volume (RV)
- 4 Lung capacities - composed of 2 or more volumes
 - Total lung capacity (TLC)
 - Vital capacity (VC)
 - Inspiratory capacity (IC)
 - Functional residual capacity (FRC)



ATS/ERS Guidelines

- Series "ATS/ERS Task Force : Standardisation of Lung Function Testing"
 - General considerations for lung function testing - European Respiratory Journal, Vol 26 (1), July 2005, pp 153-161
 - Standardisation of spirometry - European Respiratory Journal, Vol 26 (2), August 2005, pp 319-338
 - Interpretive strategies for lung function testing - European Respiratory Journal, Vol 26 (5), November 2005, pp 948-968.
- Recommendations for a Standardized Pulmonary Function Report- American Journal of Respiratory & Critical Care Medicine, Vol 196, 2017, 1463-1472.

Performing Spirometry

- Forced Vital Capacity Maneuver
 - Maximal volume of air exhaled with maximally forced effort from a maximal inspiration
 - 3 distinct phases
 - Maximal inspiration – largest source of error is inadequate maximal inspiration
 - "Blast" of exhalation
 - Continued complete exhalation to the end of test (no volume change = -0.025 L over 1 sec)

Eur Respir J 2005;26:319-38

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Eur Respir J 2005;26:319-38

Performing Spirometry

- Check spirometer calibration
- Preparatory instructions
 - Avoid smoking within 1 hour
 - Avoid alcohol within 4 hours
 - Avoid vigorous exercise within 30 minutes
 - Avoid constricting clothing of chest/abdomen
 - Avoid a large meal within 2 hours
 - Avoid loose fitting dentures
- Prepare the subject
 - Ask about smoking, medication, illness, pain, etc
 - Measure standing height and weight
- Explain and demonstrate the test

Eur Respir J 2005;26:319-38

Performing Spirometry

- Wash hands
- Patient in correct posture
 - Seated
 - Back straight, head elevated
- Attach nose clips
- Ensure tight seal of mouth on mouthpiece (generally behind the teeth and on top of tongue)
- A well-motivated, enthusiastic nurse or technician is key

Eur Respir J 2005;26:319-38

Performing Spirometry

- Inhale completely and rapidly with <1 sec pause at TLC
- Exhale maximally completely until no more air can be expelled while maintaining posture
- Repeat with coaching as necessary (warn patient)
 - "Blast it out !!!" as opposed to "blow"
 - "Keep going, keep going !!!". "More, more, more !!!"
- Perform minimum of 3 maneuvers, no more than 8 are usually required

Eur Respir J 2005;26:319-38

Most Common Errors

- Lack of motivated and enthusiastic patient coaching
- Failure of patient to take a complete inhalation prior to exhalation
- Failure to request enough efforts from the subject to acquire their best effort
- Patient stops exhaling too soon. Adults minimum of 6 seconds, children at least 3 seconds
- Patient obstructed mouthpiece with teeth or tongue
- Slow test start = patient didn't "blast" the air out at the beginning of the test
- Patient coughed during test

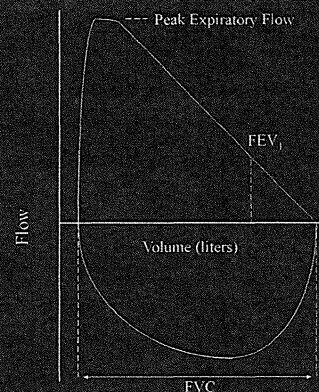
Eur Respir J 2005;26:319-38

Clinical Data Gathered

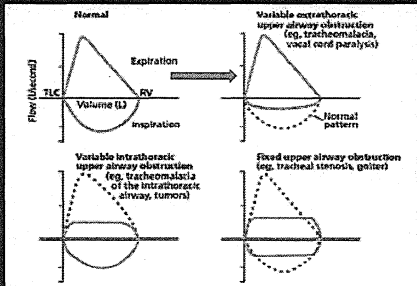
- Forced Vital Capacity (FVC) maneuver
- Graphic displays
 - Flow Volume Loop
 - Volume vs time curve
- Measurements
 - FVC = forced vital capacity
 - FEV₁ = forced expiratory volume in one second
 - Ratio FEV₁/FVC
 - FET = forced expiratory time
 - Not recommended*
 - FEF₂₅₋₇₅ = "midflows" = MMEF (Maximal Mid-Expiratory Flows)
 - PEFR = peak expiratory flow rate

Flow-Volume Loops

- Recognition of characteristic patterns of abnormalities
- Recognition of poor effort or mistakes by patient that make absolute numbers unreliable
- Directly determine peak flow
- Directly determine FVC



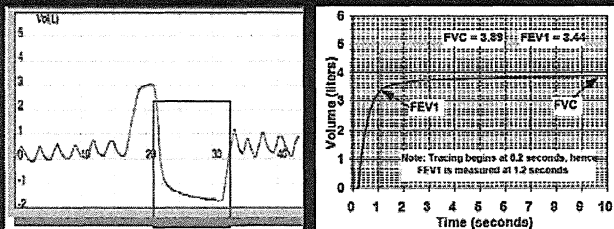
Flow-Volume Loops: Patterns



Volume vs Time Curve

- Recognition of characteristic patterns of abnormalities
- Recognition of duration of test and timing of events that make absolute numbers unreliable
- Directly determine FEV₁
- Directly determine total expiratory time (TET)
- Directly determine FVC

Volume vs Time Curve



NIOSH Spirometry Training Guide, cd.cdc.gov/niosh

FVC

- Forced Vital Capacity
- Full inspiration to total lung capacity
- Rapid, forceful, maximal expiration
- Effort dependent
- Presentation*
 - Value in liters
 - Referenced lower limit of normal
 - Referenced Z score
 - Referenced % predicted
 - Do not present the predicted value

Am J Respir Crit Care Med 2017;196:1463-1472

FEV₁

- Based on FVC maneuver
- Forced expiratory volume in one second
- Volume expired in the first second
- Effort dependent
- Presentation*
 - Value in liters
 - Referenced lower limit of normal
 - Referenced Z score
 - Referenced % predicted
 - Do not present the predicted value

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FEV₁/FVC Ratio

- Not an independent test - simply mathematical relationship
- Presentation*
 - Presented as an absolute ratio (ie 0.72)
 - ONLY use the absolute ratio
 - Do not present as % (not 72%)
 - Referenced lower limit of normal
 - Referenced Z score
 - Definitely do not present as % predicted

Am J Respir Crit Care Med 2017;196:1463-1472

FEV₁/FVC Ratio

- Key Factors
 - FEV₁/FVC ratio < lower limit of normal indicates obstructive pattern
 - Most sensitive measure of obstruction
- Severity of obstruction is determined by FEV₁

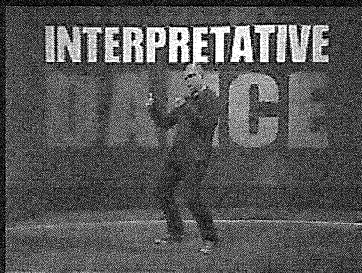
Am J Respir Crit Care Med 2017;196:1463-1472

Midflows

- FEF_{25-75%}
- MMEF = maximal mid expiratory flow rate
- Not recommended for use or in report*
- Have not demonstrated added value for identifying obstruction in adults or children

Am J Respir Crit Care Med 2017;196:1463-1472

Interpretation



multimediaenglish.org

Assessment of Normal Values

- Comparison with "normal/healthy" subjects
- Anthropomorphically similar
 - Sex
 - Age
 - Height
 - Race
- All parameters from the same reference pool

Eur Respir J 2005;26:948-68
Am J Respir Crit Care Med 2017;196:1463-1472

Assessment of Normal Values

- Comparison with "normal/healthy" subjects
- Anthropomorphically similar
 - Sex
 - Age
 - Height
 - Race – should include Caucasian, African American, NE Asian, SE Asian, Mixed or Other *
- All parameters from the same reference pool
 - Global Lung Function Initiative (GLI) – 2012 (Quanjer 2012) *
 - Can continue Hankinson (NHANES III) if continuity important

Eur Respir J 2005;26:948-68
Am J Respir Crit Care Med 2017;196:1463-1472

Grading Adequacy

- Direct observation for proper effort
- Acceptability and reproducibility criteria
- Acceptability
 - Examination of tracing and values within maneuver
 - A good start – no hesitation (extrapolated volume criteria available)
 - Sharp peak in first 25% of FVC (not ATS)
 - Flow/volume loop smooth without notching or artifact
 - No early cough
 - No early termination/glottic closure
 - Adequate duration and end of test
 - Effort is ≥ 3 sec in children <10 yo
 - Effort is ≥ 6 sec in subject age > 10 yo
 - No change in volume for >1 second (plateau in VT curve)

Eur Respir J 2005;26:948-68

Grading Adequacy

- **Reproducibility**
 - Comparison between maneuvers
 - 3 acceptable spirometrys
 - 2 best FVC and FEV1 measures within 0.150 L of each other
- **Grading Criteria***
 - Provide feedback to technician & identifies limitations that may impact interpretation of results
 - Can be used manually or as part of spirometry software
 - Grade FEV1 and FVC separately
 - Grading system consists of ATS/ERS acceptability and reproducibility guidelines

Eur Respir J 2005;28:948-68
Am J Respir Crit Care Med 2017;196:1463-1472

Grading Adequacy

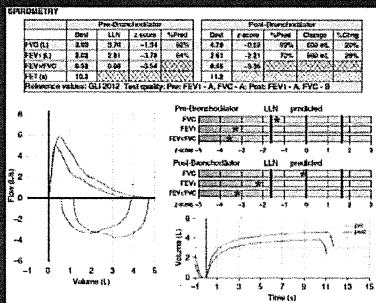
Table 1. Quality Categories for FVC or FEV1, in Adults and Children

Grade	Criteria for Adults and Older Children and for Children Aged 2-6 Years
A	→ 3 acceptable tests with repeatability within 0.150 L for age 2-6, 0.100 L, or 10% of highest value, whichever is greater
B	→ 2 acceptable tests with repeatability within 0.150 L for age 2-6, 0.100 L, or 10% of highest value, whichever is greater
C	→ 2 acceptable tests with repeatability within 0.200 L for age 2-6, 0.150 L, or 10% of highest value, whichever is greater
D	→ 2 acceptable tests with repeatability within 0.250 L for age 2-6, 0.200 L, or 10% of highest value, whichever is greater
E	One acceptable test
F	No acceptable tests

- Clinically useful = Grades A, B, C
- Should not use = Grades D, E, F

Am J Respir Crit Care Med 2017;196:1463-1472

2017 ATS Reporting Standards



Am J Respir Crit Care Med 2017;196:1463-1472

2017 ATS Reporting Standards

SPIDROMETRY

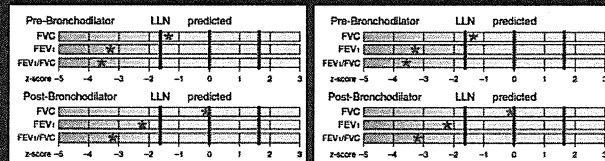
	Pre-Bronchodilator				Post-Bronchodilator				
	Best	LLN	z-score	%Pred	Best	z-score	%Pred	Change	%Chng
FVC (L)	3.90	3.70	-1.34	82%	4.70	-0.09	99%	600 mL	20%
FEV1 (L)	2.02	2.91	-3.78	54%	2.61	-2.21	70%	590 mL	28%
FEV1/FVC	0.52	0.68	-3.54		0.55	-3.35			
FET (s)	10.3				11.2				

Reference values: GLI 2012 Test quality: Pre: FEV1 - A, FVC - A; Post: FEV1 - A, FVC - B

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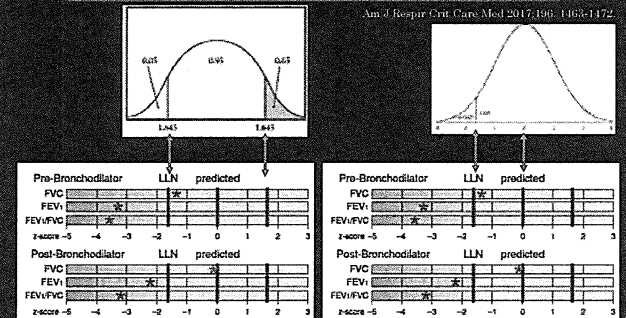
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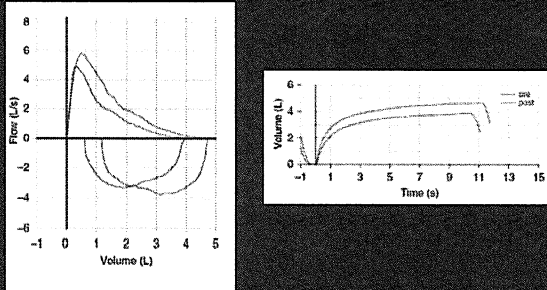


2017 ATS Reporting Standards

Am J Respir Crit Care Med 2017;196:1463-1472



2017 ATS Reporting Standards

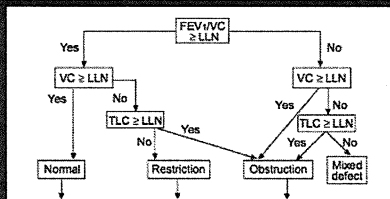


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Approach to Evaluation

- Epidemiologically and specialty based bias puts us generally on the hunt for obstructive lung disease
- Begin with the most sensitive and a defining measure of obstructive lung disease
- Begin with FEV₁/FVC

Approach to Evaluation



Eur Respir J 2005;26:948-68

Table 1 Criteria for assessing chronic obstructive pulmonary disease according to various organisations, listed by year

Organisation	Year/Ref	Criterion
ECCS	1963 ³	FEV ₁ /VC or FEV ₁ /FVC < LLN
ATS	1987 ⁸	FEV ₁ /FVC < 0.75
ATS	1991 ⁴	FEV ₁ /FVC < LLN
ECCS/ERS	1993 ⁵	FEV ₁ /VC or FEV ₁ /FVC < LLN
ERS	1995 ⁶	FEV ₁ /VC < 88% predicted (males) or 89% (females)
BTS	1997 ⁹	FEV ₁ /FVC < 0.70 and FEV ₁ < 80% predicted
NLHEP	2000 ¹³	FEV ₁ /FVC or FEV ₁ /FEV _{0.5} < LLN and FEV ₁ < LLN
GOLD	2007 ¹	FEV ₁ /FVC < 0.70 post-bronchodilator
NICE	2004 ¹⁵	FEV ₁ /FVC < 0.70 and FEV ₁ < 80% predicted
ATS/ERS	2004 ¹¹	FEV ₁ /FVC < 0.70 post-bronchodilator
ATS/ERS	2005 ¹²	FEV ₁ /VC < LLN

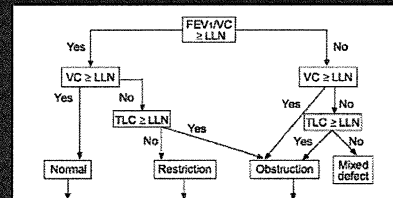
ATS, American Thoracic Society; BTS, British Thoracic Society; ECCS, European Community for Coal and Steel; ERS, European Respiratory Society; FEV₁/FVC, forced expiratory volume in 1 s/forced vital capacity; GOLD, Global Initiative for Chronic Obstructive Lung Disease; LLN, lower limit of normal; NICE, National Institute for Health and Clinical Excellence; NLHEP, National Lung Health Education Program; VC, vital capacity.

Eur Respir J 2005;26:948-68

Reference Equations

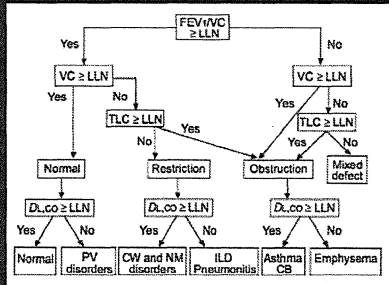
- Use published reference pools
 - GLI 2012, Quanjer 2012
- Use established LLN Fixed value
- Do not use
 - EPR3 for FEV₁/FVC
 - 6-19 yo < 85%
 - 20-39 yo < 80%
 - 40-59 yo < 75%
 - 60-80 yo < 70%
 - Other Set Cut Offs
 - FEV₁/FVC ratio < 70% (Underestimates in children/young adults)
 - FEV₁ and FVC less than 80%
 - Lung volumes < 80% and > 120%

Approach to Evaluation



Eur Respir J 2005;26:948-68

Approach to Evaluation

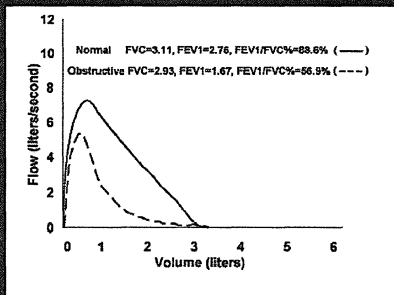


Eur Respir J 2005;20:948-68

Obstructive Abnormalities

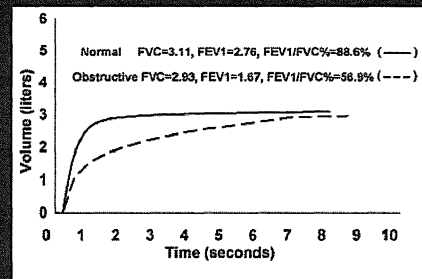
- Disproportionate reduction in maximal airflow (FEV₁) in relation to the maximal volume (VC)
- Implies airway narrowing
- Defined by FEV₁/VC ratio below LLN
- Earliest changes are slowing in terminal portion of spirogram leading to concave shape "scooping"

Obstructive Abnormalities



NIOSH Spirometry Training Guide - v2.00 (final)

Obstructive Abnormalities



NIOSH Spirometry Training Guide - v2.00 (final)

Severity Classification

TABLE 6 Severity of any spirometric abnormality based on the forced expiratory volume in one second (FEV₁)

Degree of severity	FEV ₁ % pred
Mild	>70
Moderate	60-69
Moderately severe	50-59
Severe	35-49
Very severe	<35

% pred: % predicted.

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Severity Classification

Classification of Asthma Severity (Youths ≥12 years of age and adults)			
Intermittent	Persistent		
	Mild	Moderate	Severe
≤2 days/week	>2 days/week but not daily	Daily	Throughout the day
≤2x/month	3-4x/month	>1x/week but not nightly	Often 7x/week
≤2 days/week	>2 days/week but not >1x/day	Daily	Several times per day
None	Minor limitation	Some limitation	Extremely limited
<ul style="list-style-type: none"> Normal FEV₁ between observations FEV₁ >80% predicted FEV₁/FVC normal 	<ul style="list-style-type: none"> FEV₁ ≥80% predicted FEV₁/FVC normal 	<ul style="list-style-type: none"> FEV₁ >60% but <80% predicted FEV₁/FVC reduced ≥5% 	<ul style="list-style-type: none"> FEV₁ <60% predicted FEV₁/FVC reduced >5%

EPR3 - www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf

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Summary

- Background
- Spirometry
 - New ATS guidance
 - Data Gathered
 - Interpretation
 - Report Formatting
- Approach to evaluation
- Severity classification