The Latest & Greatest 2019 Update to the ATS/ERS Guidelines: Standardization of Spirometry

Seminar # 2503

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Disclosures

• No disclosures

• The views expressed are those of the presenter and do not reflect the official views or policy of the Department of Defense or its components
Learning Objectives

- Identify the source and relevance of the ATS/ERS guidelines for lung function testing and reporting
- Discuss the ATS/ERS recommendations for correct performance and reporting of spirometry
- Identify ATS/ERS guidelines to interpret and classify the severity of identified abnormalities
Sources

• ATS/ERS sources
  • Standardisation of spirometry - European Respiratory Journal, Vol 26 (2), August 2005, pp 319-338
  • ATS website = https://www.thoracic.org/statements/pulmonary-function.php
Overview

• Background
• Spirometry and ATS/ERS guidance
  • Performance of test – new 2019
  • Interpretation
    • Assessment of normal – new 2017 & 2019
    • Reference pools – new 2017
    • Determining adequacy – new 2017 & 2019
• Approach to evaluation
• Severity classification
Instrumentation

• Spirometer
  • Meets standards of ISO 26782 reviewed 2016

http://health.allrefer.com/pictures-images/spirometry.html
Instrumentation

• Spirometer
  • Meets standards of ISO 26782 reviewed 2016
  • Flow-volume and volume-time displays explicitly required
Instrumentation

- Spirometer
  - Meets standards of ISO 26782 reviewed 2016
  - Flow-volume and volume-time displays explicitly required
- 3 L calibration syringe for daily calibration
Performing Spirometry

• Preparatory instructions
  • Avoid smoking within 1 hour
  • Avoid alcohol/intoxicants within 4 hours 8 hours
  • Avoid vigorous exercise within 30 min 1 hour
  • Avoid constricting clothing of chest/abdomen
  • Avoid loose fitting dentures

• Prepare the subject
  • Ask about illness, pain, smoking, medication, etc
  • Measure standing height and weight

• Explain and demonstrate the test

Performing Spirometry

- Wash hands – operator and patient
- Quiet comfortable environment (drinking water, tissues)
- Patient in correct posture
  - Seated erect
  - Shoulders slightly back, chin elevated
  - Seated in chair with arms, without wheels, feet flat on floor
- Attach nose clips
- Ensure tight seal of mouth on mouthpiece (generally behind the teeth and on top of tongue)
- A well-trained, well-motivated, enthusiastic nurse or technologist is key

Performing Spirometry in COVID19 Era

- Screen patients acknowledging difficulties
- Limit tests to essential for immediate treatment decisions
- Reassess risk/benefits over time
- Measures to protect staff and patients
  - PPE that limits aerosolized droplet acquisition in accord with your infection control team
    - Gowns
    - Gloves
    - N-95
    - Face shield or googles
  - Enhanced cleaning, wiping down surfaces with appropriate cleansers
  - Negative pressure room if available (it is not for us)
  - Determine room air exchange to assess dormant interval between tests (1 hour for us)

https://www.thoracic.org/professionals/clinical-resources/disease-related-resources/pulmonary-function-laboratories.php
Performing Spirometry
Performing Spirometry

- Forced Vital Capacity Maneuver
  - From a maximal inspiration, the maximal volume of air exhaled with maximally forced effort
  - 4 distinct phases
    1. Maximal inspiration – largest source of error is inadequate maximal inspiration
    2. “Blast” of exhalation
    3. End of forced expiration (no volume change = plateau = <0.025 L over 1 sec) but no longer than 15 seconds – second largest source of error is ending prematurely
    4. Inspiration at maximal flow back to maximal lung volume

Performing Spirometry

- Exhale maximally and completely until no more air can be expelled (maintain posture)
- Use “vigorous” coaching (warn patient)
  - “Blast it out !!!” as opposed to “blow”
  - “Keep going, keep going !!!”, “More, more, more !!!”
  - “Squeeze it out … until your lungs are completely empty”
- There is no longer a minimum requirement for FET (previously 6 sec – adult; 3 sec – child)
Performing Spirometry

- Inspire with maximal effort until completely full
  - “Completely fill your lungs back up”
- Perform minimum of 3 maneuvers
  - No more than 8 are usually required
  - Except children may benefit from more than 8
Most Common Errors

• Patient
  • Failure to take a complete inhalation prior to exhalation
  • Stops exhaling too soon
  • Slow test start = didn't "blast" out at beginning of test
  • Obstructed mouthpiece with teeth or tongue
  • Cough during test

• Technologist
  • Failure to request enough efforts to obtain best effort
  • Insufficient motivation & enthusiasm to obtain best effort
Clinical Data Gathered

- Forced Vital Capacity (FVC) maneuver
- Graphic displays
  - Flow Volume Loop – single best effort
  - Volume vs time curve – single best effort
Flow-Volume Loops

- Recognize characteristic patterns
- Recognize poor effort or mistakes
- Directly determine peak flow
- Directly determine FVC
Flow-Volume Loop

https://www.stepwards.com/?page_id=8403
Flow-Volume Loops: Patterns

- Normal
- Variable extrathoracic upper airway obstruction (e.g., tracheomalacia, vocal cord paralysis)
- Variable intrathoracic upper airway obstruction (e.g., tracheomalacia of the intrathoracic airway, tumors)
- Fixed upper airway obstruction (e.g., tracheal stenosis, goiter)

https://www.slideshare.net/arjunchhetri121/bedside-respiratory-assessment-spirometry
Volume vs Time Curve

- Recognize characteristic patterns
- Recognize poor effort or mistakes and when they occur during the maneuver
- Directly determine FEV1
- Directly determine total expiratory time (TET)
- Directly determine FVC
Volume vs Time Curve

The Volume–Time Curve (The Spirogram)

- FVC
- FEV<sub>1</sub>

Volume in litres

Time (s)

1 second

Forced Expiratory Time (FET)

www.slideshare.net/ashrafeladawy/spirometry-basics
Cough in First Second
Delete Curve; Correction: Try a drink of water

DHHS (NIOSH) Publication No. 2011-135
No Plateau Before 15 Seconds
Coach: Keep blowing until told to stop

Does not flatten for 1 second

Difficult to see on this curve

DHHS (NIOSH) Publication No. 2011-135
Hesitation; Slow Start; Large Extrapolated Volume
Delete Curve; Coach: Blast FASTER

Slow take off

Peak shifted to right

DHHS (NIOSH) Publication No. 2011-135
Poor Initial Blast
Coach: Blast air out HARDER

- Slow climb
- Rounded or flat peak

VOLUME (L) (BTPS)

FLOW (L/s) (BTPS)

TIME (sec)

VOLUME (L) (BTPS)

DHHS (NIOSH) Publication No. 2011-135
Incomplete Inhalation
Coach: Take a DEEPER breath

Curves have same shape but are different sizes
Clinical Data Gathered

- Forced Vital Capacity (FVC) maneuver
- Measurements
  - FVC = forced vital capacity
  - FEV$_1$ = forced expiratory volume in one second
  - Ratio FEV$_1$/FVC
  - FET = forced expiratory time
  - Not recommended 2017 but may use in 2019*
    - FEF$_{25-75}$ = “midflows” = MMEF (Maximal Mid-Expiratory Flows)
    - PEFR = peak expiratory flow rate
- New in 2019
  - FIVC
FVC

- Forced Vital Capacity
- Effort dependent
- Presentation*
  - Value in liters
  - Referenced lower limit of normal
  - Referenced Z score
  - Referenced % predicted (mean)
  - Do not present the predicted (mean) value

Am J Respir Crit Care Med 2017;196: 1463-1472.
2017 ATS Reporting Standards

**Table: Spirometry**

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FEV$_1$

- Forced expiratory volume in one second
- Effort dependent
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FEV₁/FVC Ratio

• Not an independent test - simply mathematical relationship

• Presentation*
  • Presented ONLY as an absolute ratio (ie 0.72)
  • Do not present as % (not 72%)
  • Referenced lower limit of normal
  • Referenced Z score
  • Definitely do not present as % predicted (mean)

Am J Respir Crit Care Med 2017;196: 1463-1472.
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FEV₁/FVC Ratio

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

- FEF$_{25-75\%}$
- MMEF = maximal mid expiratory flow rate
- 2017
  - Not recommended for use or in report*
  - Have not demonstrated added value for identifying obstruction in adults or children
- 2019
  - May be reported without endorsing it

Grading Adequacy

- Direct observation for proper effort
- Acceptability criteria – within each test/effort
- Reproducibility criteria – between tests/efforts
Grading Adequacy

• Acceptability
  • Examination of tracing and values within maneuver
  • A good start - no hesitation (extrapolated volume criteria available)
  • Sharp rise in peak flow
    • Rise from 10% to 90% PEF should be ≤150 milliseconds
    • Within first 25% of FVC (not ATS)
  • Flow/volume loop smooth without notching or artifact
    • No early cough
    • No early termination/glottic closure
  • Adequate duration when end of forced expiration (EOFE) – not end of test (EOT)
    • No change in volume (<0.025 L) for >1 second (plateau in VT curve)
    • Effort is > 15 sec
    • No minimum time (no longer ≥ 3 sec in children and ≥ 6 sec in adults)
  • FIVC – FVC ≤ 0.100 L or 5% of FVC – whichever is greater
Grading Adequacy

• Reproducibility
  • Comparison between maneuvers
  • 3 acceptable spiromgrams
  • FVC and FEV1 graded independently
  • 2 best FVC and FEV1 measures
    • Within 0.150 L of each other for > 6 yo
    • Within 0.100 L or 10% of largest FVC whichever greater for ≤ 6 yo

Eur Respir J 2005;26:948-68.
Am J Respir Crit Care Med 2017;196: 1463-1472.
## Table 1. Quality Categories for FVC or FEV\textsubscript{1} in Adults and Children

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<tr>
<th>Grade</th>
<th>Criteria for Adults and Older Children and for Children Aged 2–6 Years</th>
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<tr>
<td>A</td>
<td>$\geq 3$ acceptable tests with repeatability within $0.150 \text{ L}$ for age 2–6, $0.100 \text{ L}$, or $10%$ of highest value, whichever is greater</td>
</tr>
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<td>B</td>
<td>$\geq 2$ acceptable tests with repeatability within $0.150 \text{ L}$ for age 2–6, $0.100 \text{ L}$, or $10%$ of highest value, whichever is greater</td>
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<tr>
<td>C</td>
<td>$\geq 2$ acceptable tests with repeatability within $0.200 \text{ L}$ for age 2–6, $0.150 \text{ L}$, or $10%$ of highest value, whichever is greater</td>
</tr>
<tr>
<td>D</td>
<td>$\geq 2$ acceptable tests with repeatability within $0.250 \text{ L}$ for age 2–6, $0.200 \text{ L}$, or $10%$ of highest value, whichever is greater</td>
</tr>
<tr>
<td>E</td>
<td>One acceptable test</td>
</tr>
<tr>
<td>F</td>
<td>No acceptable tests</td>
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- Clinically useful = Grades A, B, C
- Should not use = Grades D, E, F
2019 Grading Adequacy

- Always strive for grade A
- Other results may still contain useful data

Assessment of Normal Values

• Comparison with “normal/healthy” subjects
• Anthropomorphically similar
  • Birth Sex
  • Age (years to one decimal place)
  • Height
  • Ethnicity – 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) *

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2017 ATS Reporting Standards
Interpretation

• Comment on quality of test and effort
  • Less than optimal may still contain useful data
  • Identify the problem, direction and magnitude of possible error
• Comparisons
  • Reference values from healthy subjects
  • Known disease or physiologic patterns
  • Self (changes over time)
• Answer clinical question posed or that prompted test
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
- Determine if above or below LLN
  - Do not use “preset” cut off (ie 0.7)
Approach to Evaluation
Obstructive Abnormalities

- Disproportionate reduction in maximal airflow ($FEV_1$) in relation to the maximal volume ($VC$)
- Implies airway narrowing
- Defined by $FEV_1/VC$ ratio below LLN
- Earliest changes are slowing in terminal portion of spirogram leading to concave shape “scooping”
Obstructive Abnormalities

Obstructive FVC = 2.93, FEV1 = 1.67, FEV1/FVC% = 56.9% (—-—)

Normal FVC = 3.11, FEV1 = 2.76, FEV1/FVC% = 88.6% (———)

Obstructive FVC = 2.93, FEV1 = 1.67, FEV1/FVC% = 56.9% (—-—)

Obstructive FVC = 2.93, FEV1 = 1.67, FEV1/FVC% = 56.9% (—-—)
# Severity Classification

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

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<th>Degree of severity</th>
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% pred: % predicted.
Restrictive Abnormalities

- **Definition**
  - TLC below LLN (5\(^{th}\) percentile, 80%?)
  - Normal FEV1/VC

- **Spirometry**
  - Reduced FVC
  - Normal or increased FEV1/FVC
  - Convex pattern to FV loop

- **Spirometry can be misleading – need lung volumes**
  - Effort
  - Obstruction with air trapping
  - Pattern is associated with low TLC only ~ 50% time
Restrictive Abnormalities

Normal FVC=4.21, FEV1=3.46, FEV1/FVC%=82% (———)
Restrictive FVC=3.16, FEV1=2.59, FEV1/FVC%=82% (-----)

Flow (liters/second)

Volume (liters)

Time (seconds)
Mixed Abnormalities

- Coexisting restriction and obstruction
- Defined by abnormally reduced FEV1/VC and low TLC
Mixed Abnormalities
Grading Adequacy

• Acceptability
  • Examination of tracing and values within maneuver
  • A good start - no hesitation (extrapolated volume criteria available)
  • Sharp rise in peak flow
    • Rise from 10% to 90% PEF should be ≤150 milliseconds
    • Within first 25% of FVC (not ATS)
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    • No change in volume (<0.025 L) for >1 second (plateau in VT curve)
    • Effort is > 15 sec
    • Effort FVC is reproducible
    • No minimum time
  • FIVC – FVC ≤ 0.100 L or 5% of FVC – whichever is greater

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Approach to Evaluation
Severity Classification

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    • Reference equations
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