Session 2314
2012 NIOSH Report: Is Your Office Meeting Spirometry Quality Assurance Standards?
2013 AAAAI Annual Meeting Interactive Workshop
Mary Kay Bossard BS RRT AE-C
Maureen George PhD RN AE-C FAAN
Tina Tolomeo DNP APRN FNP-BC AE-C

Disclosures
Mary Kay Bossard BS RRT AE-C
- Speaker and/or Consultant
  - Pharmaxis
Maureen George PhD RN AE-C FAAN
- Speaker
  - Merck, Pharmaxis, Novartis, Sunovion
- Consultant
  - Novartis
Concettina Tolomeo DNP APRN FNP-BC AE-C
- Financial
  - Sage Publications: Editor Journal of Asthma and Allergy Educators

Objectives
• The learner will demonstrate an understanding of how common errors impact spirometry results
  - The 12 most common errors in obtaining office spirometry will be reviewed including details of the problem, its implication for interpreting test results and its required solution
• The learner will have the opportunity to practice hands on skills to remediate these common errors
Reference

Spirometry Quality Assurance:
• Common Errors and Their Impact on Test Results
  — DHHS (NIOSH) Publication No. 2012-116

Why is accuracy so important?
• Accurate spirometry testing, interpretation, and follow-up are critical
• Spirometry quality assurance includes examination of test values and evaluation for evidence of technical errors.
  — Technically poor spirometry may have little value and may even provide misleading information.
  — When erroneous curves are detected, additional maneuvers are often needed.

Standards for a Valid Normal Test
• During testing, technicians should attempt to record a valid test
  • at least 3 acceptable maneuvers with consistent ("repeatable") results for both FVC and FEV1.
  • Achieving repeatability during testing means that the difference between the largest and second largest values for both FVC and for FEV1 are within 0.15 l (150 ml).
  • Additional maneuvers can be attempted, up to a maximum of 8, to meet these criteria for a valid test.
When should tests NOT be interpreted?

• Tests should not be interpreted if fewer than 2 acceptable curves were recorded, reflecting the fact that useful information may be present even in tests that are not optimal.
• Some medical conditions prevent patients from successfully recording valid tests, in spite of the best efforts of the technician and the subject to produce such results.
• Clinical judgment should be used to determine whether curves are so unacceptable that they would lead to a misinterpretation of respiratory health.

1994, the American Thoracic Society

NIOSH: The 12 Common Errors

• Error #1: Sub-maximal Inhalation
• Error #2: Excessive Extrapolated Volume
• Error #3: Sub-maximal Blast
• Error #4: Cough in First Second
• Error #5: Early Termination
• Error #6: Variable Effort
• Error #7: Cessation of Airflow – Glottis Closure or Breath Holding
• Error #8: Partially Obstructed Mouthpiece
• Error #9: Leak
• Error #10: Extra Breath(s)
• Error #11: Positive Zero-Flow Error
• Error #12: Negative Zero-Flow Error
Acceptable Tests

- Satisfactory start of exhalation
  - No false start
  - No hesitation
- No cough in the first second
- No early termination of expiration
- No Valsalva manoeuvre (glottis closure)
- No evidence of leak
- No evidence of obstruction of the mouthpiece
- No evidence of an extra breath during the manoeuvre
- Satisfactory duration of test
  - Duration of ≥ 6 seconds (3 seconds for children) or a plateau in the volume-time curve or if the subject cannot or should not continue to exhale

ATS/ERS Task Force. (2005). Standardisation of Spirometry

Submaximal Inhalation

Implication(s)
- Falsely low FVC
- Potential for non-repeatability

Resolution
- Encourage patient to fill lungs

2012 NIOSH Spirometry Quality Assurance: Common Errors and Their Impact on Test Results
Cough in First Second

Implication(s)
- Falsely high or low FEV1
- Falsely low FVC
- Inaccurate FEV1/FVC

Resolution
- Offer glass of water

Early Termination
### Early Termination

**Implication(s)**
- Falsely low FVC
- Falsely increased FEV1/FVC

**Resolution**
- Encourage patient to KEEP BLOWING

### Cessation of Airflow

**Implication(s)**
- Falsely low FVC
- Falsely increased FEV1/FVC

**Resolution**
- Encourage patient to BLOW OUT UNTIL THEY ARE INSTRUCTED TO STOP.
- Practice relaxed breathing
Extra Breaths

Implication(s)
- Falsely increased FVC
- Falsely low FEV1/FVC

Resolution
- Use nose clips
- Encourage patients to keep a tight seal

Variable Effort
Variable Effort

Implication(s)
• Falsely low FEV1
• Falsely low FEV1/FVC

Resolution
• Encourage patient to BLAST OUT HARD AND FAST AND KEEP BLOWING

Excessive Extrapolated Volume

• Hesitation in exhaling before the initial “big blast”
• Most readily seen in flow-volume curve as peak is displaced to the right
• “Vext” is reported measure
  – Unacceptable > than 0.15 liters or 5% of FVC whichever is greater
• Many spirometers will have error message

Excessive Extrapolated Volume

2012 NIOSH Spirometry Quality Assurance: Common Errors and Their Impact on Test Results
Excessive Extrapolated Volume

• Implications
  – Inaccurate, usually elevated FEV1
  – Infrequently decreases FEV1

• Resolution
  – Coaching can correct
  – Instruct to blow out “faster” or “immediately”

Sub-maximal Effort (blast)

• Poor effort at initial “peak flow”
• Affects early maneuver measurements
• Flow-volume curve: Peak is reduced: weaker effort = lower PF
• Volume-Time curve: curve rises slowly, not sharply from baseline
• Spirometers may or may not label this as an error – must be recognized
Sub-maximal Effort (blast)

- Implications
  - Inaccurately lower FEV1 and FEV1/FVC ratio
  - May falsely indicate obstruction
  - May find variable FEV1 despite reproducibility

- Resolution
  - Coach to blow out the air “harder”
  - Demonstration of technique may be very helpful

Partially Obstructed Mouthpiece

- Implications/Identification
  - Airflow reduced or slowed
  - Reduced FEV1 and FEV1/FVC % may falsely indicate obstruction
  - Flow Volume Loop: decreased PF and portions of loop may be flattened
  - Volume Time Curve: Initial rise followed by flattening
  - Air puffing in cheeks

- Resolution
  - Keep mouthpiece between teeth and on top of tongue
  - Secure dentures if possible – lightly biting on mouthpiece may help
  - Remove if necessary
  - NOTE: No spirometer error message – must be detected by health professional.

Partial Blockage by tongue, teeth or loose dentures

- Implications/Identification
  - Airflow reduced or slowed
  - Reduced FEV1 and FEV1/FVC % may falsely indicate obstruction
  - Flow Volume Loop: decreased PF and portions of loop may be flattened
  - Volume Time Curve: Initial rise followed by flattening
  - Air puffing in cheeks

- Resolution
  - Keep mouthpiece between teeth and on top of tongue
  - Secure dentures if possible – lightly biting on mouthpiece may help
  - Remove if necessary
  - NOTE: No spirometer error message – must be detected by health professional.
Leaks

- Leak can occur in spirometer, hose or around mouthpiece
- Volume and flow measurements both will be falsely low
- NOTE: Must be detected during calibration check – there will be not an error message displayed by spirometer

Implications
- If leaks are visible on graphs the effect on FVC will be large
- FEV1 not affected so ratio falsely higher
- May prevent obstruction from being realized or falsely report restrictive pattern

Resolution
- Volume spirometers – more common; must perform leak check
- Flow spirometers leak will not show on graphs; will fail calibration
- Assure tight seal around mouthpiece – should be able to hear if air is escaping
Positive Zero Flow Error

- Occurs in flow type spirometer
- Zero flow reference point is incorrectly set
- Over records all measurements
- NO error message from spirometer – must be recognized
- Volume-time curve will rise constantly and never plateau – greater the error, steeper the slope
- Long “tail” in flow volume loop

Implications
- False obstructive pattern
- Increased FVC without an effect on FEV1

Resolution
- Prevent air movement through sensor when zero-flow is setting
- Hold upright and still
- Zero-flow determined either before each FVC or just at the beginning of testing session
- All zero-flow error loops must be deleted
Negative Zero-Flow Error

- Again in flow type spirometers
- “Under records” all measurements
- Occurs when zero-flow reference is set incorrectly
- Volume time curve may drop gradually towards zero or just end
- No error message – must be recognized

Implications
- False increased FEV1/FVC ratio
- FVC affected not FEV1
- May wrongly indicate restriction or falsely mask obstruction

Resolution
- Prevent air movement through sensor when zero-flow is setting
- Hold upright and still
- Zero-flow determined either before each FVC or just at the beginning of testing session
- All zero-flow error loops must be deleted
Hands On Practice