ABC’S OF SPIROMETRY
IN PRIMARY CARE
PRESENTERS AND FACILITATORS

MERIDENE HAYNES – St. Joseph’s Healthcare Firestone Institute for Respiratory Health – North Hamilton CHC

MADONNA FERRONNE – Asthma Research Group Inc. – Hotel Dieu Grace Hospital, Windsor

LAURIE TAYLOR - Somerset West CHC, Ottawa

KAREN JONES – Merrickville – Lanark CHC

JANICIE WOYCHYSHYN - RVH, Barrie CHC

NATALIA UDARCHIK - Stonegate CHC, Toronto
WORKSHOP FORMAT

ABC’s of Spirometry

- Importance of Spirometry
- Indications/ contraindications
- Equipment Requirements/minimum (lower limit of normal, Predicted values, EMR capability)
- Quality Assurance

Spirometry Practical: Hands On

- 4-5 stations with Spirometer and Facilitator
- Demographics / predicted values
- Calibration/ “QC process”
- Flow volume loops/ time volume curve - showing Acceptability and Repeatability
- Spirometry Reports – content requirements

Resources

- PCAP Spirometry Manual Policies & Procedures
- ATS/ERS 2005 Guidelines
Spirometry, or the “measure of breath” is the most common of the pulmonary function tests that uses a spirometer to measure the amount of air one can inhale fully and exhale completely.

Spirometry also measures the rate of airflow through the airways, meaning how fast the air goes through the airways.

**SPIROMETRY is an important diagnostic test** that is used to diagnose and monitor respiratory disease. And used much the same way that blood pressure provides important information about general cardiovascular health.
INDICATIONS FOR SPIROMETRY

Diagnostic
- To diagnose the presence of respiratory disease
- To evaluate respiratory symptoms
- To assess progression of respiratory disease
- To correlate with abnormal x ray/ tests
- To measure the effect of disease on pulmonary function
- To screen individuals at risk of having respiratory disease
- To assess pre-operative risk
Monitoring

- To assess therapeutic intervention
- To monitor the course of diseases that affect lung function
- To monitor people exposed to injurious agents
- To monitor for adverse reactions to drugs with known pulmonary toxicity
Disability/impairment evaluations
- To assess patients as part of a rehabilitation programme
- To assess risks as part of an insurance evaluation
- To assess individuals for legal reasons

Public Health
- Epidemiological surveys
- Derivation of reference equations
- Clinical research

Ref: 2005 ATS/ERS Standardisation of Spirometry – M.R. Miller et al.
Canadian Thoracic Society (CTS) Statement

- Confirm diagnosis with history and objective lung function measurements (CTS 2010 Management of Asthma for 6 years and over)

- Early diagnosis, confirmed by spirometry is key to optimal management (CTS 2008 COPD update)
“Should play a central role any time a physician prescribes potent bronchoactive and anti-inflammatory drugs…”

Large proportion of patients with respiratory disease are followed in primary care. We need to identify and monitor at this point of care.

Petty, T.L. “Benefits of and Barriers to the Widespread Use of Spirometry”. Current Opinions in Pulm Medicine, 2005, 11:115-120.
Forced Vital Capacity (FVC) maneuver may raise intracranial, intra-thoracic and intra-abdominal pressures so relative contraindications as per ATS 2005 are:

- Recent eye, thoracic or abdominal surgery
- Recent MI, uncontrolled hypertension or embolism
- Recent Cerebrovascular hemorrhage or known cerebral or abdominal aneurysm
- Pneumothorax
- Hemoptysis of unknown origin (FVC maneuver may aggravate underlying condition.)
- Acute disorders affecting test performance (e.g. vomiting, nausea, vertigo)
If you are older than 40 years of age and are a current or ex-smoker, you may be at risk for Chronic Obstructive Pulmonary Disease (COPD). Take the Canadian Lung Health Test to see if you have signs and symptoms of COPD

1. Do you cough regularly? Yes No

2. Do you cough up phlegm regularly? Yes No

3. Do even simple chores make you short of breath? Yes No

4. Do you wheeze when you exert yourself, or at night? Yes No

5. Do you get frequent colds that persist longer than those of other people you know? Yes No
THE 30 SECOND ASTHMA TEST

Do you use your blue reliever inhaler 4 or more times a week?
   Yes    No

Do you cough, wheeze, or have a tight chest because of your asthma?
   Yes    No

Do coughing, wheezing, or chest tightness wake you at night one or more times a week?
   Yes    No

Do you stop exercising because of your asthma?
   Yes    No

Do you ever miss work, school, or social activities because of your asthma?
   Yes    No

GlaxoSmithKline Inc 2004
# CTS Asthma Control

<table>
<thead>
<tr>
<th>Category</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime Symptoms</td>
<td>&lt; 4 days/week</td>
</tr>
<tr>
<td>Night time symptoms</td>
<td>&lt;1 night/week</td>
</tr>
<tr>
<td>Physical Activity</td>
<td>Normal</td>
</tr>
<tr>
<td>Exacerbations</td>
<td>Mild, infrequent</td>
</tr>
<tr>
<td>Absence from work/school due to asthma</td>
<td>None</td>
</tr>
<tr>
<td>Need for fast acting B2</td>
<td>&lt;4 days/week</td>
</tr>
<tr>
<td>FEV1 of PEF</td>
<td>&gt; 90% personal best</td>
</tr>
<tr>
<td>PEF diurnalal variation</td>
<td>&lt; 10 – 15 %</td>
</tr>
</tbody>
</table>
### Measurement | Abbreviation | Definition
--- | --- | ---
**Forced Vital Capacity (L)** | FVC | Maximum volume of air that can be expired as forcefully, quickly and completely as possible following a complete inspiration.

**Forced Expiratory Volume in 1 second (L/sec)** | FEV1 | Volume of air expired in the first second of the FVC – used to assess flow of air, reflecting the flow resistive properties of the airway.

**Ratio of FEV1 to FVC** | FEV1/FVC | Used for the assessment of airflow obstruction ATS/ERS.

**Peak Expiratory Flow (L/sec)** | PEF | The maximum flow rate at the onset of the FVC maneuver – judges max effort.

**Forced Expiratory Flow 25-75%** | FEF 25-75 | The average flow rate during the middle half of the FVC maneuver – reflects airflow.
Medication to withhold:

Inhaled bronchodilators (ATS/ERS 2005)

Short-acting (SABA) 4 hours
Anticholinergics 4 hours
Long-acting (LABA) 12 hours

Please note that patients should be instructed to take their reliever for symptoms if they require it and not withhold prior to testing.
PATIENT PREPARATION

- Take height without shoes, and weight
- Check for contraindications
- Note recent inhaler usage, if any
- Enter patient data: age, height, weight, gender, race
PERFORMING SPIROMETRY

- Patient should be seated with both feet flat on the ground.
- Explain test and keep instructions simple. Breath normally for a few breaths – then take a big breath in, then blow that air out as hard, fast and as long as you can.
- Demonstrate: Actions speak louder than words. 
  Demonstrate with animation.
- Lips sealed around mouthpiece, noseclips recommended.
- Coach – Appropriately.
Evaluate each patient individually
Decide on appropriate teaching/coaching methods
Demonstrate test
Evaluate each attempt during and after
Make recommendations and adjustments accordingly
If necessary, stop the test and review instructions
Repeat all substandard tests
Attempt no more than 8 attempts (fatigue)
Provide feedback on report to relay any pertinent information to physician
PATIENT RELATED PROBLEMS

Flow Volume Curve

Time Volume Curve
Figure 5. Normal versus inadequate spirometry tracings. The value of pattern recognition cannot be overemphasized in the interpretation of spirometry results.
### TABLE 3: SUMMARY OF WITHIN- AND BETWEEN-MANOEUVRE ACCEPTABILITY/REPEATABILITY CRITERIA

**Within-manoeuvre criteria**

Individual spirograms are “acceptable” if:
- They are free from artefacts [3]
- Cough during the first second of exhalation
- Glottis closure that influences the measurement
- Early termination or cut-off
- Effort that is not maximal throughout
- Leak
- Obstructed mouthpiece

They have good starts
- Extrapolated volume < 5% of FVC or 0.15 L, whichever is greater
- They show satisfactory exhalation
- Duration of ≥6 s (3 s for children) or a plateau in the volume–time curve or
- If the subject cannot or should not continue to exhale

**Between-manoeuvre criteria**

After three acceptable spirograms have been obtained, apply the following tests:
- The two largest values of FVC must be within 0.150 L of each other
- The two largest values of FEV1 must be within 0.150 L of each other

If both of these criteria are met, the test session may be concluded.

If both of these criteria are not met, continue testing until:
- Both of the criteria are met with analysis of additional acceptable spirograms or
- A total of eight tests have been performed (optional) or
- The patient/subject cannot or should not continue

Save, as a minimum, the three satisfactory manoeuvres

**FVC**: forced vital capacity;
**FEV1**: forced expiratory volume in one second.

Ref: 2005 ATS/ERS STANDARDISATION OF SPIROMETRY M.R. MILLER ET AL.
Perform FVC maneuver

Met within-maneuver acceptability criteria?

No

Met between maneuver repeatability criteria?

No

Achieved three acceptable maneuvers?

No

No

Yes

Yes

Determine largest FVC and largest FEV₁
Select maneuver with largest sum of
FVC+FEV₁ to determine other indices

Store and interpret
ASTHMA

- Typically the curve is a smooth concave shape as the airway obstruction is relatively stable throughout expiration.

COPD

- Typically the curve is angled as the damaged airways in COPD collapse with forced expiration.

RESTRICTIVE

- Typically the curve is of normal height, but very steep as the lung volume is decreased.
Reversible airway obstruction is documented with improvement in FEV₁ of > 12% and >200 ml in adults.

Failure to demonstrate a change after bronchodilator does not exclude a reversible component of obstruction because airway inflammation may be present and not responsive to B₂ agonist.
### SUMMARY OF EQUIPMENT QUALITY CONTROL

<table>
<thead>
<tr>
<th>Test</th>
<th>Min. Interval</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>Daily</td>
<td>Calibration check with a 3 – L syringe</td>
</tr>
<tr>
<td>Leak</td>
<td>Daily***</td>
<td>3cm H₂O (0.3 kPa) constant pressure for 1 min</td>
</tr>
<tr>
<td>Flow linearity</td>
<td>Weekly</td>
<td>Test at least three different flow ranges</td>
</tr>
<tr>
<td>Volume linearity</td>
<td>Quarterly</td>
<td>1-L increments with a calibrating syringe measured over entire volume range</td>
</tr>
<tr>
<td>Software</td>
<td>New versions</td>
<td>Log installation date and perform test using “known” subject. Monthly Biologicals ensures reproducibility and equipment variability</td>
</tr>
</tbody>
</table>

***Daily leak checks are done only on spirometers that measure volume directly. This is not necessary for most portable spriometers as they are flow measuring devices that convert the flow to a volume.

Adapted from “ATS/ERS Task Force: Standardization of Lung Function Testing” Etd. V. Brusasco, et al, Standardization of spirometry Number 2 in this series.
QA program ensures attaining the highest quality test data

Equipment – must meet minimum requirements for test protocol (accuracy, precision, sensitivity, frequency response, response time, biological controls, maintenance schedule)

Staff – adequately trained in performing spirometry

Test procedures – policy and procedure manual (including infection control, equipment maintenance, calibration process, test procedures)

Reporting and Interpretation – predicted values documented and results as per ATS/ERS standards, interpretation done by qualified professional.
ATS recommended predicted values:

- HAYNES III, 1999 for those aged 8–80 yrs,
- Wang, for children aged 8 yrs
- Knudson, 1976, 1983, (Caucasian only, use .85 for race correction)
- Crapo, (commonly used for diffusion capacity)

Canadian Predicted Values set
This is a plot of the FEV₁ measured from a group of normal, non-smoking men who were all 60 years old and 180 cm tall.

The predicted value for FEV₁ for someone in this group is 3.5L.

The shaded area represents 5% of normal men, age 60, height 180 cm, with the lowest FEV₁.

This defines the Lower Limit of Normal (LLN).

LLN for FEV₁ for this group is 2.6L

5% of the population with normal lungs have FEV₁ below LLN

95% of the population with normal lungs have FEV₁ above LLN

Ref: MR Miller – www.millermr.com
The Lower Limit of the Normal (LLN)

- The predicted value calculated from spirometry reference equations is the *average or mean value* observed from many healthy persons of the same age, gender, height, and ethnic group.

- The predicted value is actually in the middle of a rather wide, bell-shaped distribution (range) of normal values. For instance, some healthy persons may have FVC values as much as 20% lower than the predicted value.

- The lower limit of the normal range (LLN) is the threshold below which a value is considered abnormal - usually the value is set so that 95% of a “normal” population will have values above the LLN value and correspondingly, 5% of a “normal” population will have values below the LLN.

- The LLN is about 80% of the predicted value for FEV1 and for FVC, but about 90% of the predicted value for the FEV1/FVC ratio, and about 60% of the predicted value for the FEF25-75%.

- However, these are only rough rules of thumb and the exact LLN should be determined using the reference equations. If a race correction factor is used (0.85), the same race correction factor should be applied to the LLN value.

Some spirometry systems and some sets of normal values do not report LLN.

Be sure to choose a spirometry system and a set of normal values that reports LLN.

If LLN is not available, the alternative is to use 80% of the predicted value as an estimate of LLN.
## Operator Checklist

<table>
<thead>
<tr>
<th>Item</th>
<th>✔️</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB and Temp updated / Daily Calibration performed</td>
<td></td>
</tr>
<tr>
<td>Contraindications assessed</td>
<td></td>
</tr>
<tr>
<td>Minimum of three attempts recorded</td>
<td></td>
</tr>
<tr>
<td>No hesitation or cough within first second of exhalation</td>
<td></td>
</tr>
<tr>
<td>Extrapolated volume &lt; 150 ml or 5% of FVC</td>
<td></td>
</tr>
<tr>
<td>No glottic closure or early termination</td>
<td></td>
</tr>
<tr>
<td>Six seconds of exhalation collected (3 sec for &lt;10 yrs)</td>
<td></td>
</tr>
<tr>
<td>Are the two largest FVCs within 150 ml of each other?</td>
<td></td>
</tr>
<tr>
<td><strong>If FVC &lt; 1.0 L then criteria is within 100ml of each other</strong></td>
<td></td>
</tr>
<tr>
<td>Are the two largest FEV1s within 150 ml of each other?</td>
<td></td>
</tr>
<tr>
<td><strong>If FVC &lt; 1.0 L then criteria is within 100ml of each other</strong></td>
<td></td>
</tr>
<tr>
<td>Comments recorded on test results?</td>
<td></td>
</tr>
</tbody>
</table>

### Contraindications:

- Recent pneumonitis
- Recent myocardial infarction
- Recent ophthalmic, thoracic or abdominal surgery
- Hemoptysis of unknown origin
- Presence or suspected active tuberculosis or other communicable respiratory disease

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### Quick reference for “techs” to follow

- Reminder about updating temperature, barometric pressure and daily calibration

- Highlights acceptability and reversibility criteria

- Feedback to physician about patient effort


OLA/OTS Provider Education Program, [http://olapep.ca/](http://olapep.ca/)