SPIROMETRY TECHNIQUE

Jim Reid   New Zealand
SPIROMETRY TECHNIQUE

The Basics

Jim Reid
Spirometry measures airflow and lung volumes, and is the preferred lung function test in COPD. By measuring reversibility of obstruction, it is also diagnostic in asthma. However normal spirometry does not exclude asthma.
SPIROMETRY TECHNIQUE

Any test is only as good as its accuracy
# SPIROMETRY TECHNIQUE

<table>
<thead>
<tr>
<th><strong>FORCED VITAL CAPACITY (FVC)</strong></th>
<th>Volume of air exhaled after full inspiration and full exhalation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FORCED EXPIRATORY VOLUME IN 1 second (FEV1)</strong></td>
<td>Volume of air exhaled in the first second of exhalation.</td>
</tr>
<tr>
<td><strong>FEV1 / FVC</strong></td>
<td>Ratio of vital capacity exhaled in 1 second expressed as a percentage</td>
</tr>
<tr>
<td><strong>% Predicted</strong></td>
<td>Uses normal values for age, sex and height.</td>
</tr>
</tbody>
</table>
SPIROMETRY TECHNIQUE

PEAK EXPIRATORY FLOW RATE (PEFR)

Measures flow in large airways

Of limited use in COPD, but is useful for diagnosis and management of asthma

Relationship between FEV1 and PEFR is poor in COPD (closer in asthma)
SPIROMETRY TECHNIQUE

Factors that influence normal values

Height - tall people have larger lungs

Age - Respiratory function declines with age

Sex - Lung volumes smaller in females

Race - Peculiarly studies show Black and Asian people as a whole, have smaller lung volumes (-12%) No studies for Pacific People.

Posture - little difference between sitting and standing. Reduced in supine position.

Nose clip – must use a nose clip.
SPIROMETRY TECHNIQUE

OBSTRUCTION

- FEV1 / FVC < 70%
- FEV1 < 80% of predicted value
- In severe COPD the FVC may be < 80% predicted - Much less in fact because of air trapping.
SPIROMETRY TECHNIQUE

Severity of Obstruction

FEV1
Mild >70% Predicted
Moderate 50 - < 69% Predicted
Severe <50% Predicted
## SPIROMETRY TECHNIQUE
### Severity

<table>
<thead>
<tr>
<th>GOLD Level</th>
<th>EXACERBATIONS Per Year</th>
<th>HOSPITAL Per Year</th>
<th>3 year MORTALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOLD 1</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Mild</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOLD 2</td>
<td>0.7 – 0.9</td>
<td>0.11 – 0.2</td>
<td>11%</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOLD 3</td>
<td>1.1 – 1.3</td>
<td>0.25 – 0.3</td>
<td>15%</td>
</tr>
<tr>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOLD 4</td>
<td>1.2 – 2.0</td>
<td>0.4 -0.54</td>
<td>24%</td>
</tr>
<tr>
<td>Very Severe</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SPIROMETRY TECHNIQUE

RESTRICTION

Both FEV1 and FVC < 80%  BUT the FEV1/FVC ratio is normal or high
Severity of Restriction

FVC
Mild  >65 - 80% predicted
Moderate  >50 - 65% predicted
Severe  <50% predicted.
SPIROMETRY TECHNIQUE

Asthma

Both FEV1 & FVC are reduced, but can demonstrate reversibility of at least 12%. Because asthma is an episodic disease, spirometry may be normal.
### Valid Normal Test

<table>
<thead>
<tr>
<th>Trial</th>
<th>FVC (L)</th>
<th>FEV₁ (L)</th>
<th>PEF (L/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.81</td>
<td>4.09</td>
<td>12.1</td>
</tr>
<tr>
<td>2</td>
<td>4.74</td>
<td>4.07</td>
<td>12.0</td>
</tr>
<tr>
<td>3</td>
<td>4.87</td>
<td>4.14</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Repeatability</strong></td>
<td><strong>0.06</strong></td>
<td><strong>0.05</strong></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{4.87-4.81 = 0.06} \quad \text{4.14-4.09 = 0.05}
\]
What is a good quality trace?

The blow should continue until a volume plateau is reached - this may take more than 12 seconds in severe COPD.

FVC and FEV₁ readings should be within 5% or 100 ml of each other.

The expiratory volume-time graph should be smooth and free from irregularities.
Reasons for unacceptable / unreliable readings:

Common problems include:

• Inadequate or incomplete inhalation
• Lack of blast effort during exhalation
• Additional breath taken during manoeuvre
• Lips not tight around the mouthpiece
• Slow start to the forced exhalation
• Exhalation stops before complete expiration
• Some exhalation through the nose
• Coughing.
Recognizing Common Errors in Spirometry technique

### Error #1: Sub-maximal Inhalation

<table>
<thead>
<tr>
<th></th>
<th>FVC (L)</th>
<th>FVC % Pred</th>
<th>FVC LLN (L)</th>
<th>FEV₁ (L)</th>
<th>FEV₁ % Pred</th>
<th>FEV₁ LLN (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Effort</td>
<td>4.90</td>
<td>96</td>
<td>4.17</td>
<td>4.17</td>
<td>103</td>
<td>3.29</td>
</tr>
<tr>
<td>Error</td>
<td>4.18</td>
<td>82</td>
<td>4.17</td>
<td>3.60</td>
<td>88</td>
<td>3.29</td>
</tr>
</tbody>
</table>

4.90 - 4.18 = 0.72

Falsely reduced FVC can be misinterpreted as indicating a “restrictive impairment.”
Recognizing Common Errors in Spirometry technique

**Error #2: Excessive Extrapolated Volume**

<table>
<thead>
<tr>
<th></th>
<th>FVC (L)</th>
<th>FEV₁ (L)</th>
<th>FEV₁ % Pred</th>
<th>PEF (L/sec)</th>
<th>Vext (L)</th>
<th>Vext (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Effort</td>
<td>4.79</td>
<td>4.12</td>
<td>86</td>
<td>12.2</td>
<td>0.12</td>
<td>2.5</td>
</tr>
<tr>
<td>Error</td>
<td>4.78</td>
<td>3.95</td>
<td>82</td>
<td>8.5</td>
<td>0.55</td>
<td>11.5</td>
</tr>
</tbody>
</table>

**Spirometer Error Messages:** Most spirometers label this error with “Hesitation,” “Large extrapolated volume,” or “Start faster.”

- peak flow displaced to the right
- unacceptable if it exceeds 0.15 liters or 5% of the FVC, whichever is larger.
Recognizing Common Errors in Spirometry technique

The peak on the curve is reduced, indicating insufficient subject effort

Coach the subject to blast the air out HARDER
Recognizing Common Errors in Spirometry technique

Error #4: Cough in First Second

<table>
<thead>
<tr>
<th></th>
<th>FEV₁ (L)</th>
<th>FEV₁ % Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Effort</td>
<td>4.12</td>
<td>88</td>
</tr>
<tr>
<td>Error</td>
<td>3.96</td>
<td>84</td>
</tr>
</tbody>
</table>

A cough can cause either a falsely reduced or falsely elevated FEV₁
Recognizing Common Errors in Spirometry technique

Error #5: Early Termination

<table>
<thead>
<tr>
<th></th>
<th>FVC (L)</th>
<th>FVC % Pred</th>
<th>FEV₁ (L)</th>
<th>FEV₁ % Pred</th>
<th>FEV₁/FVC%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>4.54</td>
<td>83</td>
<td>3.91</td>
<td>87</td>
<td>86</td>
</tr>
<tr>
<td>Error</td>
<td>3.81</td>
<td>67</td>
<td>3.76</td>
<td>84</td>
<td>98</td>
</tr>
</tbody>
</table>

Falsely reduced FVC may be misinterpreted as indicating a “restrictive impairment.” The falsely increased FEV1/FVC ratio may cause a true “obstructive impairment” to be missed.
Strive for good quality Spirometry

The blow should continue until a volume plateau is reached - this may take more than 12 seconds in severe COPD.

FVC and FEV₁ readings should be within 5% or 100 ml of each other.

The expiratory volume-time graph should be smooth and free from irregularities.
FEV6

- Represents the forced expiratory volume in 6 seconds.
- Excludes incomplete FVC
- Normal values are in existence
- Still controversial
- Of little use in diagnosis of restriction and asthma