Diagnosing **Asthma**: Spirometry & interpretation in the primary care practice setting, “Yes, it **CAN** be done!”

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US Naval Officer
Objective Overview

1. What is **Asthma** really?

2. How is a spirometry test performed in the Primary Care clinic or what are the components of a spirometry test?

3. Obstructive Vs. Restrictive Values- Identifying the disease.

The Purpose of Spirometry

Provide a quantifiable, reproducible, identifiable measurement of lung function
Asthma - Over diagnosed or Under Misinterpreted?

- Chronic inflammatory disease of the airways
- Most common childhood chronic disease
- Affects ~4.8 million (CDC, 1995)
- >100 million days of restricted activity
- Nine million children age 18 and younger (or 13%) have been diagnosed with asthma, with more than four million children (6%) suffering an asthma attack in the past 12 months.
- 470,000 hospitalizations/yr
Epidemiology

- Asthma was first recognized by Hippocrates more than 2000 years ago.
- It remains one of the most common diseases encountered in clinical medicine.
- Over the past decade the incidence of asthma has increased dramatically.
- It is estimated that more than 25 million Americans have asthma.
About 500,000 Americans are hospitalized annually for severe asthma

About 4000 die as a result of asthma annually

According to the World Health Organization, about 180,000 people worldwide die from asthma

Among young children, asthma is about two times more prevalent in boys than girls

After puberty, however, asthma is more common in girls
Table 13. Twenty leading primary diagnosis groups for office visits: United States, 2016

<table>
<thead>
<tr>
<th>Primary diagnosis group and ICD-9-CM code(s)</th>
<th>Number of visits in thousands</th>
<th>Percent distribution (standard error)</th>
<th>Femoral percent distribution (standard error)</th>
<th>Male percent distribution (standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine infant or child health check V00.0-V02.2</td>
<td>44,634 (4,724)</td>
<td>4.4 (0.4)</td>
<td>37 (0.4)</td>
<td>5.4 (0.6)</td>
</tr>
<tr>
<td>Essential hypertension 401</td>
<td>36,916 (3,649)</td>
<td>3.6 (0.6)</td>
<td>31 (0.6)</td>
<td>4.4 (0.6)</td>
</tr>
<tr>
<td>Anthropodites and related disorders 710-719</td>
<td>36,130 (3.999)</td>
<td>3.6 (0.4)</td>
<td>37 (0.4)</td>
<td>3.4 (0.3)</td>
</tr>
<tr>
<td>Acute upper respiratory infections, excluding pharyngitis 460-461,463-466</td>
<td>32,207 (3,102)</td>
<td>3.2 (0.3)</td>
<td>32 (0.3)</td>
<td>3.3 (0.3)</td>
</tr>
<tr>
<td>Sinus disorders 720-724</td>
<td>31,953 (4,165)</td>
<td>3.1 (0.4)</td>
<td>29 (0.4)</td>
<td>3.5 (0.4)</td>
</tr>
<tr>
<td>Diabetes mellitus 249-250</td>
<td>35,560 (4,369)</td>
<td>3.0 (0.4)</td>
<td>25 (0.4)</td>
<td>3.8 (0.5)</td>
</tr>
<tr>
<td>Malignant neoplasms 140-208,209-215,217-219,230-234</td>
<td>25,155 (4,110)</td>
<td>2.5 (0.4)</td>
<td>26 (0.4)</td>
<td>3.4 (0.4)</td>
</tr>
<tr>
<td>Rheumatism, excluding back 725-729</td>
<td>21,835 (2,262)</td>
<td>2.2 (0.2)</td>
<td>24 (0.3)</td>
<td>1.9 (0.2)</td>
</tr>
<tr>
<td>Normal pregnancy V02</td>
<td>20,779 (2,596)</td>
<td>2.1 (0.2)</td>
<td>36 (0.4)</td>
<td>...</td>
</tr>
<tr>
<td>General medical examination V70</td>
<td>15,705 (1,668)</td>
<td>2.0 (0.2)</td>
<td>15 (0.2)</td>
<td>2.5 (0.3)</td>
</tr>
<tr>
<td>Gynecological examination V72.3</td>
<td>16,645 (2,402)</td>
<td>1.6 (0.2)</td>
<td>26 (0.4)</td>
<td>...</td>
</tr>
<tr>
<td>Follow-up examination V47</td>
<td>15,063 (2,130)</td>
<td>1.6 (0.2)</td>
<td>16 (0.2)</td>
<td>1.4 (0.2)</td>
</tr>
<tr>
<td>Otitis media and eustachian tube disorders 381-382</td>
<td>14,650 (1,455)</td>
<td>1.5 (0.1)</td>
<td>1.1 (0.1)</td>
<td>1.9 (0.2)</td>
</tr>
<tr>
<td>Specific processes and atresia V59-V59.9</td>
<td>14,286 (1,398)</td>
<td>1.4 (0.2)</td>
<td>1.3 (0.3)</td>
<td>1.6 (0.2)</td>
</tr>
<tr>
<td>Asthma 493</td>
<td>14,232 (2,195)</td>
<td>1.4 (0.2)</td>
<td>1.4 (0.3)</td>
<td>1.5 (0.2)</td>
</tr>
<tr>
<td>Heat disease, excluding ischemic 390-392,393-397,410-414,415-416,420-429</td>
<td>12,405 (1,156)</td>
<td>1.2 (0.1)</td>
<td>1.2 (0.1)</td>
<td>1.3 (0.1)</td>
</tr>
<tr>
<td>Disorders of lipid metabolism 272</td>
<td>13,340 (1,777)</td>
<td>1.3 (0.2)</td>
<td>0.9 (0.3)</td>
<td>1.4 (0.3)</td>
</tr>
<tr>
<td>Cataract 366</td>
<td>11,266 (1,900)</td>
<td>1.1 (0.2)</td>
<td>1.2 (0.2)</td>
<td>1.0 (0.2)</td>
</tr>
<tr>
<td>Allergic rhinitis 477</td>
<td>11,057 (2,529)</td>
<td>1.1 (0.2)</td>
<td>1.0 (0.2)</td>
<td>1.2 (0.3)</td>
</tr>
<tr>
<td>Benign neoplasms 210-229,230-239,240-249</td>
<td>10,663 (1,131)</td>
<td>1.1 (0.1)</td>
<td>1.1 (0.1)</td>
<td>1.0 (0.1)</td>
</tr>
<tr>
<td>All other diagnoses 575,331</td>
<td>27,339</td>
<td>65.3 (0.3)</td>
<td>56.3 (1.0)</td>
<td>55.0 (1.1)</td>
</tr>
</tbody>
</table>

*Category not applicable.

1Based on the International Classification of Diseases, Ninth Edition. 
2Includes all other diagnoses not listed above, as well as unrecorded birth diagnoses.

NOTE: Numbers may not add to total because of rounding.

SOURCE: CDC/NCHS, National Ambulatory Medical Care Survey
Risk Factors

- **Extrinsic asthma (Allergic or Atopic asthma)**
  - Asthma episodes clearly linked to the exposure of a specific allergen (antigen):
    - House dust
    - Mites
    - Furred animal dander
    - Cockroach allergen
    - Fungi
    - Molds
    - Yeast
Figure 12-2. The immunologic mechanisms in asthma.
Conducting Airways

Air travels via laminar flow through the conducting airways comprised of the following: trachea, lobar bronchi, segmental bronchi, subsegmental bronchi, small bronchi, bronchioles, and terminal bronchioles.
Figure 12-3. Some factors known to trigger intrinsic asthma.
Child - Asthma

Current Asthma Prevalence Percents by Age, Sex, and Race/Ethnicity, United States, 2011

- Child: 9.5%
- Adult: 8.2%
- Male: 7.2%
- Female: 9.7%
- White: 8.2%
- Black: 11.6%
- Hispanic: 7.3%

Source: National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention
Adult-onset asthma

- Many situations
- Allergens important
- Non-IgE asthma have nasal polyps, sinusitis, aspirin sensitivity or NSAID sensitivity

Idiosyncratic asthma less understood

Percentage of adults who are obese

Click on Data to Show State
Adult-onset asthma

Occupational exposure

animal products, biological enzymes, plastic resin, wood dusts, metal

removal from workplace may improve symptoms although symptoms persist in some
Asthma Among American Indians in Minnesota

The Minnesota Department of Health Asthma Program tracks different aspects of asthma (e.g., the percentage of Minnesota residents with asthma, rates of asthma-related hospitalizations, and emergency department visits) to better understand the burden of asthma in Minnesota. Currently there is no information on the percentage of American Indians in Minnesota who have asthma, or statistics that could be used to describe the burden of asthma in this group. However, there are indications that the burden may be high based on data from the Minnesota Student Survey, the Minnesota Department of Human Services, and other sources.

What We Know:
Minnesota Student Survey
Data from the 2007 Minnesota Student Survey show that American Indian students in grades 6, 9, and 12 are more likely than other students to have ever been diagnosed with asthma.

Percentage (%) of students reporting “Yes” to “Has a doctor or nurse ever told you that you have asthma?” by grade and race/ethnicity

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Grade 6</th>
<th>Grade 9</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian</td>
<td>20.1</td>
<td>24.3</td>
<td>25.4</td>
</tr>
<tr>
<td>Asian American/Pacific Islander</td>
<td>10.1</td>
<td>12.3</td>
<td>12.3</td>
</tr>
<tr>
<td>Black, African or African-American</td>
<td>23.1</td>
<td>24.8</td>
<td>23.4</td>
</tr>
<tr>
<td>Hispanic</td>
<td>14.0</td>
<td>18.2</td>
<td>19.6</td>
</tr>
<tr>
<td>White</td>
<td>13.7</td>
<td>17.9</td>
<td>18.8</td>
</tr>
</tbody>
</table>

Source: Minnesota Student Survey, 2007

Data Source: IHS General Data Mart, 2008-2009

Among active users of tribal health care in Minnesota:
- 7% of preschool aged children have asthma
- 5% of school aged children have asthma
- 1-2 students in a classroom of 30
- 4% of young to middle aged adults have asthma
- 9% of adults and 16% of the elderly have asthma
Minnesota Youth Tobacco and Asthma Survey

Results from the Minnesota Youth Tobacco and Asthma Survey show that 26% of American Indian students in grades 6-12 have a history of asthma and 22% currently have asthma. There are notable differences in the prevalence of asthma by race/ethnicity among Minnesota youth; however, these none of these differences is statistically significant (i.e., all within the margin of error).

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Ever diagnosed</th>
<th>Still has asthma</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian</td>
<td>25.8%</td>
<td>22.4%</td>
</tr>
<tr>
<td>Asian American/Pacific Islander</td>
<td>18.6%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Black, African or African-American</td>
<td>20.5%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>12.7%</td>
<td>6.6%</td>
</tr>
<tr>
<td>White</td>
<td>16.8%</td>
<td>12.2%</td>
</tr>
</tbody>
</table>

Source: Minnesota Youth Tobacco and Asthma Survey, 2011

*Yes to: Has a doctor or nurse ever told you or your parents that you have asthma?
*Yes to: During the past 12 months, have you had wheezing, tightness in your chest or other symptoms of asthma? and Has a doctor or nurse ever told you or your parents that you have asthma?

Relative standard error is greater than 30%, thus results may be unreliable.

Minnesota Health Care Programs

Among enrollees in Minnesota’s Medical Assistance program, 5.7% of American Indians had “persistent” asthma compared with 3.0% of Asians, 7.7% of Blacks, 5.0% of Hispanics and 5.2% of Whites. Among enrollees in MinnesotaCare, the prevalence of “persistent” asthma was highest in American Indians at 9.9% compared with Asians (2.7%), Blacks (6.0%), Hispanics (4.8%) and Whites (5.5%). (See Figure 3.) Note that this data source includes only those American Indians enrolled in Medical Assistance or MinnesotaCare and does not completely overlap with IHS data. (Note: See MDH Asthma Program report “Asthma in Minnesota 2012 Epidemiology Report” for definition of persistent asthma.)

Figure 5. Percentage of enrollees with persistent asthma by program and race/ethnicity

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Medical Assistance</th>
<th>Minnesota Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian</td>
<td>4.7%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>1.3%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Black</td>
<td>1.4%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.1%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Other</td>
<td>1.4%</td>
<td>3.0%</td>
</tr>
<tr>
<td>White</td>
<td>1.2%</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

Source: Minnesota Department of Human Services Data Warehouse, 2010

Figure 4. Rate of asthma-related hospitalizations, emergency department visits and office visits by race/ethnicity among enrollees in Medical Assistance, 2010

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Hospitalizations</th>
<th>ED Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian</td>
<td>200.0</td>
<td>75.4</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>48.7*</td>
<td>28.9*</td>
</tr>
<tr>
<td>Black</td>
<td>339.4</td>
<td>125.1</td>
</tr>
<tr>
<td>Hispanic</td>
<td>162.9</td>
<td>40.6</td>
</tr>
<tr>
<td>Other</td>
<td>118.1</td>
<td>56.0</td>
</tr>
<tr>
<td>White</td>
<td>102.8</td>
<td>57.4</td>
</tr>
<tr>
<td>Total</td>
<td>160.1</td>
<td>69.6</td>
</tr>
</tbody>
</table>

Rate per 10,000 enrollees

*Relative standard error is greater than 30%, rate may be unreliable

Source: Minnesota Department of Human Services, 2010

Asthma-related office visits include both visits for preventative care and visits for worsening asthma symptoms. In 2010, the rate of office visits for asthma among American Indian enrollees in Medical Assistance was 537 per 10,000 compared with 613 per 10,000 for all enrollees. The
Diagnosis of Asthma

The presence of any of these signs and symptoms should increase the suspicion of asthma:

- **Wheezing**—history of any of the following:
  - Cough, worse particularly at night
  - Recurrent wheeze
  - Recurrent difficult breathing
  - Recurrent chest tightness
Diagnosis of Asthma (Cont’d)

- Symptoms occur or worsen at night, awakening the patient.
- Symptoms occur or worsen in a seasonal pattern.
- The patient also has eczema, hay fever, or a family history of asthma or atopic diseases.
Diagnosis of Asthma (Cont’d)

- Symptoms occur or worsen in the presence of:
  - Animals with fur
  - Aerosol chemicals
  - Changes in temperature
  - Domestic dust mites
  - Drugs (aspirin, beta blockers)
  - Exercise
Diagnosis of Asthma (Cont’d)

- Pollens
- Respiratory (viral) infections
- Smoke
- Strong emotional expression

Symptoms respond to appropriate anti-asthma therapy.

Patient’s colds “go to the chest” or take more than 10 days to clear up.
Test Used in the Diagnosis and Monitoring of Asthma

- Spriometry
- Peak expiratory flow
- Responsiveness to metacholine, histamine, mannitol, or exercise challenge
- Positive skin tests with allergens or measurement of specific IgE in serum
Classification of Asthma Severity by Clinical Features Before Treatment (Cont’d)

**Mild Persistent**
- Symptoms more than once a week but less than once a day
- Exacerbations may affect activity and sleep
- Nocturnal symptoms more than twice a month
- $\text{FEV}_1$ or PEF $\geq 80\%$ predicted
- PEF or $\text{FEV}_1$ variability $< 20 - 30\%$
Classification of Asthma Severity by Clinical Features Before Treatment (Cont’d)

Moderate Persistent
- Symptoms daily
- Exacerbations may affect activity and sleep
- Nocturnal symptoms more than once a week
- Daily use of inhaled short-acting $\beta_2$-agonist
  - $\text{FEV}_1$ or PEF 60 - 80% predicted
  - PEF or $\text{FEV}_1$ variability > 30%
Classification of Asthma Severity by Clinical Features Before Treatment (Cont’d)

Severe Persistent
- Symptoms daily
- Frequent nocturnal asthma symptoms
- Limitation of physical activities
  - $\text{FEV}_1$ or PEF $< 60\%$ predicted
  - PEF or $\text{FEV}_1$ variability $> 30\%$
Let's begin

**Why asthma makes it hard to breathe**

Air enters the respiratory system from the nose and mouth and travels through the bronchial tubes.

In an asthmatic person, the muscles of the bronchial tubes tighten and thicken, and the air passages become inflamed and mucus-filled, making it difficult for air to move.

In a non-asthmatic person, the muscles around the bronchial tubes are relaxed and the tissue thin, allowing for easy airflow.

Inflamed bronchial tube of an asthmatic

Normal bronchial tube
Spirometry Interpretation: So what constitutes normal?

Normal values vary and depend on:
- Height
- Age
- Gender
- Ethnicity

**NHANES III Reference Values (CDC)**

**Performance of American Thoracic Society-Recommended Spirometry Reference Values in a Multiethnic Sample of Adults**
- The Multi-Ethnic Study of Atherosclerosis (MESA) Lung Study
For now, spirometry is best test to:
- Monitor asthma status
- Look for evidence of asthma
- Look for evidence of other diagnoses

The most recent spirometry guidelines of the American Thoracic Society and European Respiratory Society (ATS/ERS) recommend reference values derived from the National Health and Nutrition Survey (NHANES) III for general use in the United States.
Spirometry

- Simple, office-based
- Measures flow, volumes
- Volume vs. Time

Can determine:

- Forced expiratory volume in one second (FEV$_1$)
- Forced vital capacity (FVC)
- FEV$_1$/FVC
- Forced expiratory flow 25%-75% (FEF$_{25-75}$)
Flow-Volume Curves and Spirograms

Two ways to record results of FVC maneuver:

- Flow-volume curve---flow meter measures flow rate in L/s upon exhalation; flow plotted as function of volume
  - Obstructive Disorder is seen more in the Flow Volu

- Classic spirogram---volume as a function of time
Normal Flow-Volume Curve and Spirogram
Forced Vital Capacity Maneuver

Airflow, L/sec

Lung volume
Volume-Time Plot
Definitions

FVC – Forced Vital Capacity

Volume of air exhaled after a maximal inspiration to total lung capacity. This volume is expressed in Liters

FEV1 – Forced Expiratory Volume in 1 second

Volume of air exhaled in the first second of expiration.
This volume is expressed in Liters

FEF 25-75%

Mean expiratory flow during the middle half of the FVC maneuver; reflects flow through later emptying airways, not necessarily the small airways

FEV1/FVC – Ratio (%)

Volume of air expired in the first second, expressed as a percent of FVC
Performance of FVC maneuver

Patient assumes the position (typically sitting)
- Puts nose clip on
- Inhales maximally
- Puts mouthpiece in mouth and closes lips around mouthpiece (open circuit)
- Exhales as hard and fast and long as possible
- Repeat instructions if necessary – effective coaching is essential
- Give simple instructions
- Repeat minimum of three times (check for repeatability)
ATS Acceptable Criteria
Within Maneuver

- Free from artifacts, such as
  - 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

- Good starts
  - Extrapolated volume < 5% of FVC or 0.15 L, whichever is greater

- Satisfactory exhalation
  - Duration of ≥ 6 s (3 s for children < 10) or a plateau in the volume–time curve or
  - If the subject cannot or should not continue to exhale
ATS Acceptable Criteria
Within Maneuver

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.
- 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 maneuvers.
Spirometry Interpretation: Obstructive vs. Restrictive Defect

**Obstructive Disorders**
- Characterized by a limitation of expiratory airflow so that airways cannot empty as rapidly compared to normal (such as through narrowed airways from bronchospasm, inflammation, etc.)

Examples:
- Asthma
- Emphysema
- Cystic Fibrosis
- CBABE

**Restrictive Disorders**
- Characterized by reduced lung volumes/decreased lung compliance

Examples:
- Interstitial Fibrosis
- Scoliosis
- Obesity
- Lung Resection
- Neuromuscular diseases
- Cystic Fibrosis
What about lung volumes and obstructive and restrictive disease?

(From Ruppel, 2003)
Acceptable and Unacceptable Spirograms (from ATS, 1994)

**Acceptable Spirogram**

**Unacceptable Spirogram**

**Variable Effort Early Termination**

**Glottis Closure**
Measurements Obtained from the FVC Curve

- **FEV$_1$** --- the volume exhaled during the first second of the FVC maneuver.

- **FEF 25-75%** --- the mean expiratory flow during the middle half of the FVC maneuver; reflects flow through the small (<2 mm in diameter) airways.

- **FEV$_1$/FVC** --- the ratio of FEV$_1$ to FVC X 100 (expressed as a percent); an important value because a reduction of this ratio from expected values is specific for obstructive rather than restrictive diseases. (Normal Ranges 70-95%)
Severity of any spirometric abnormalities based on the FEV1

<table>
<thead>
<tr>
<th>Degree of severity</th>
<th>FEV1 % predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&gt;70 or LLN</td>
</tr>
<tr>
<td>Moderate</td>
<td>60-69</td>
</tr>
<tr>
<td>Mod severe</td>
<td>50-59</td>
</tr>
<tr>
<td>Severe</td>
<td>35-49</td>
</tr>
<tr>
<td>Very Severe</td>
<td>&lt; 35</td>
</tr>
</tbody>
</table>

If FEV1/VC is < LLN ("10" down)

Based on ATS/ERS criteria
Normal vs. Obstructive vs. Restrictive

(Hyatt, 2003)
**Spirometry Interpretation: Obstructive vs. Restrictive Defect**

**Obstructive Disorders**
- FVC nl or ↓
- FEV1 ↓
- FEF25-75% ↓
- FEV1/FVC ↓
- TLC nl or ↑

**Restrictive Disorders**
- FVC ↓
- FEV1 ↓
- FEF 25-75% nl to ↓
- FEV1/FVC nl to ↑
- TLC ↓
Spirometry Interpretation: What do the numbers mean?

**FVC**

Interpretation of % predicted:
- 80-120% Normal
- 70-79% Mild reduction
- 50%-69% Moderate reduction
- <50% Severe reduction

**FEV1**

Interpretation of % predicted:
- >75% Normal
- 60%-75% Mild obstruction
- 50-59% Moderate obstruction
- <49% Severe obstruction
  - <25 y.o. add 5% and >60 y.o. subtract 5
Spirometry Interpretation: What do the numbers mean?

**FEF 25-75%**

- **Interpretation of % predicted:**
  - >79% Normal
  - 60-79% Mild obstruction
  - 40-59% Moderate obstruction
  - <40% Severe obstruction

**FEV1/FVC**

- **Interpretation of absolute value:**
  - 80 or higher Normal
  - 79 or lower Abnormal
When you see the tracings below, which of these prompts should you give the participant?

- Take in a deeper breath
- Blow out harder and faster
- Try not to cough
- Blow out longer
- Good Test
The flow volume loop below is representative of:

- Extrapolation or time zero error
- Obstructive pattern
- Clipped inspiratory loop
- Restrictive pattern
- Glottic closure
When you see the tracings below, which of these prompts should you give the participant:

- Blow out longer
- Good Test
- Take in a deeper breath
- Try not to cough
- Blow out harder and faster
When you see the tracings below, which of these prompts should you give the participant:

- Take in a deeper breath
- Blow out harder and faster
- Try not to cough
- Blow out longer
- Good Test
Exhalation Time During Obstruction

**SPIROMETRY**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pred</th>
<th>Best</th>
<th>% Pred.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC [l]</td>
<td>4.44</td>
<td>4.31</td>
<td>97</td>
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Spirometry-Induced Bronchospasm

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Trial 1 - Trial 8: Graphs showing lung function over volume.
Coaching is Key

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Diagram showing various trials and the best performance graph.
### Bronchodilator Response

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**Graphs:**

- **Volume vs. Time:**
  - Ref vs. Best

- **Flow vs. Volume:**
  - Flow vs. Volume
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<td>FEV1/FVC</td>
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Calibration:
- Pred Volume: 3.00
- Flow Cal Date: 05/24/10
- Inspire Avg: 3.00
- Expire Avg: 3.00

PF Reference: Dockety/Zapletal/Morris

Diagram showing flow and volume over time with 'PRE' and 'POST' labels.
Restrictive Pattern

<table>
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Conclusions

- Spirometry is:
  - Useful in asthma diagnosis and management
  - Useful in diagnosis of conditions that can present with wheezing, or airway noise that can be hard to distinguish from wheezing
  - Requires considerable expertise, particularly in children
  - FEF_{25-75%} does not measure small airways, but instead airways more obstructed that empty later in exhalation