Spirometry for the Primary Care Pediatrician

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Practice Gap

The 2007 National Heart, Lung and Blood Institute expert panel asthma guidelines recommend that spirometry be part of routine asthma diagnosis and monitoring of therapy, yet only 35% of pediatric practices use spirometry for patients with asthma. Pediatricians should be aware that routine office spirometry is feasible, practical, and important for optimizing care for children with respiratory symptoms or risk of lung disease.

Objectives

After completing this article, readers should be able to:

1. Understand the use of spirometry to diagnose and monitor the treatment of asthma.
2. Identify the details needed for the optimal performance and interpretation of spirometry.

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ABBREVIATIONS

$FEF_{25\%-75\%}$	forced expiratory volume between 25% and 75% of vital capacity
FET	forced expiratory time
FEV_1	forced expiratory volume in 1 second
FVC	forced vital capacity
NHLBI	National Heart, Lung, and Blood Institute

INTRODUCTION

Spirometry is a useful tool to help the practitioner distinguish normal from abnormal pulmonary function, delineate obstructive from restrictive defects, and monitor the disease or treatment. Most hospitals and many specialty offices (eg, pulmonology and allergy) have ready access to and familiarity with spirometry. The pediatric primary care practice may not have a spirometer or may lack experienced personnel to properly administer and/or interpret the test results. A published survey with data from 360 primary care practices revealed that only 52% used spirometry for patients with a diagnosis of asthma, and of those, only 35% of pediatric practices (vs 75% of family medicine practices) used spirometry in clinical practice. (1) Equipment for spirometry is readily available at a reasonable cost, and the procedure and interpretation of results are billable services that can be used by any primary care practice. The interpretation of results can be performed by the primary care physician, possibly with the help of a specialist.

Who?

Most children older than 5 years, who can cooperatively take deep breaths, can be coached to perform a good spirometry test. Younger children or those with developmental delays, certain disabling conditions, or poor behavior may not be willing or able to perform the test. (For those too young to voluntarily exhale into the spirometer, impulse oscillometry is an alternate technique that requires nothing more than passively breathing into a mouthpiece. Description of this tool is beyond the scope of discussion for this paper.) (2) Any child with respiratory symptoms or who is at risk for lung disease should have spirometry performed routinely. The 2007 NHLBI expert panel asthma guidelines recommend that spirometry be performed at diagnosis, rather than relying on measures of peak expiratory flow rates. (3)

What?

Spirometers can be of 2 general types: volume displacement or flow measurement. Those that measure volume have a (usually 10-L) drum with a piston, such that the change in volume over time is measured directly, and flow rates are calculated (change of volume over time). These devices are computer linked and usually not easily portable, tend to be more costly, and most likely would not be useful to a primary care practice.

Flow-sensing devices can be handheld and are easily portable from room to room in the office. They use disposable sensors, referred to as pneumotachometers, which sense the flow over time. This measurement of flow is used to calculate the volumes. These devices may be self-contained or connected to a laptop or desktop computer. Any spirometer used in an office setting should meet the American Thoracic Society/European Respiratory Society recommendations for spirometry (available online at http://www.thoracic.org/statements/resources/pft/pft2.pdf). (4)(5) The first chapter of this document is essential reading for all clinical staff, with descriptions of standards for hygiene, calibration, quality control, and other maintenance issues. (5)

Measurements made by the spirometer are as follows:

- Forced vital capacity (FVC): the total volume of air exhaled after maximal inhalation.
- Forced expiratory volume in 1 second (FEV_1): the volume of air exhaled in the first second. Reversibility after inhaled bronchodilator is determined by an increase in FEV_1 of 12% or more or 200 mL from baseline.
- Ratio of FEV_1 to FVC.
- Peak expiratory flow rate: the highest flow obtained during the forced expiratory maneuver, expressed as liters per second. This is different than the peak flow meter readings, which are expressed in liters per minute.
- Forced expiratory volume between 25% and 75% of vital capacity ($FEF_{25\%\text{-}75\%}$): the flow in the midportion of the forced expiratory maneuver, which is a reflection of the flow from the smaller airways.
- Forced expiratory time: the time that the patient sustains the expiratory maneuver.

Why?

There are many reasons to perform spirometry in a pediatric patient:

- To establish whether pulmonary mechanics are normal in a child with symptoms.
- To define the nature and severity of any pulmonary dysfunction (obstructive vs restrictive defect).
- To define the site of airway obstruction—central vs peripheral or intrathoracic vs extrathoracic.
- To follow the course of pulmonary disease or assess the effect of therapy.
- To establish the presence or absence of airway reactivity.
- To assess the risks of diagnostic or therapeutic procedures.
- To monitor for adverse effects of chemotherapy or radiation therapy.
- To predict prognosis or assess disability and to assess the effect of disease on lung growth.

You can do this in your office! It is important to identify what barriers exist in your office to map out a plan for sustainable change. Time, patient flow, and quality are often cited as barriers to spirometry implementation. It is important to remember that each practice is different. Some practices will group asthma visits that include spirometry (each practitioner has several dedicated asthma sessions a month); others will prereview patients before each session to develop a better patient flow strategy to allow for spirometry. An individualized implementation that matches existing practice culture appears to be the best strategy to successfully change and sustain practice patterns. (6)

Although regional (7) and distance or Internet-based training efforts (8) have been successful at improving the spirometry capacity and guideline-based asthma care in primary care pediatricians' offices, many busy practitioners still struggle with implementing and sustaining routine spirometry into their busy practice.

The planned asthma visit (Table 1) is a tool that can be used to implement spirometry in the busy practice. (9) In this model, patients with asthma can be proactively assessed for control with an asthma control test and spirometry. This is a time when trained office staff can help to identify asthma triggers in the home, school, and work environment. Medications and administration technique can be reviewed with the patient and family, and immunizations, such as influenza, can be given. Spirometry can also be performed with a bronchodilator for initial visits to help establish reversibility. Spirometry without a bronchodilator can be performed at follow-up visits to monitor control. *All this can be completed before the practitioner enters the room.* The practitioner will review all the results, examine the patient, and create or update a written action plan. Follow-up can be based on severity, asthma control, and seasonal pattern. We recommend follow-up visits in 2 to 6 weeks for asthma that is not well controlled and 3 to 6 months for asthma that is well controlled. Key points for assessing asthma control and severity and stepwise therapy have been condensed to a very usable format at the National Center for Medical Home implementation website (10) and are displayed in Appendix A (information adapted from Texas Children's Health Plan's Key Points for Asthma Guideline Implementation).

Once the pediatrician's office staff gains comfort in spirometry, it can become a useful tool in a busy practice. The information generated by spirometry will inform the patient and the practitioner when to step up and when to step down therapy.

Consider the asthma patient who is a poor perceiver of symptoms. This type of patient tends to report regular controller medication use, with good technique, rarely reports needing albuterol, and rarely notices dyspnea on exertion. When sick, this patient becomes very ill very quickly and may require intensive care. Often this patient has been to the specialist and does not feel the need for further visits because their asthma is "just fine." Spirometry results obtained in the primary care office can reveal unnoticed obstruction and provide immediate feedback to the physician, patient, and family.

COMMON PITFALLS

Calibration is a common pitfall. Because atmospheric pressure and temperature are continuously changing, volume-displacement spirometers may have to be calibrated daily. This requires a fixed-volume (usually 3-L) syringe with which to pump air into and out of the spirometer. The device then recognizes this exact volume as 3 L and is then ready to use for the day. For flow-based spirometers, the disposable pneumotachometer is factory calibrated and coded so that the software adjusts for each calibrated unit.

Another common pitfall is test performance. Office personnel who perform the spirometry have to be patient, nonthreatening, and able to get the best effort out of each patient they test. Merely purchasing a spirometer and assigning an untrained person to administer the test will not produce adequate results. The American Thoracic Society criteria for acceptable spirometry call for a 3-second exhalation in children (6 seconds for adults and older children), with a zero flow plateau at the end of the breath, and an appropriately rapid start of exhalation (back-extrapolated volume <5%). Cough, premature termination of exhalation, and lack of reproducibility between efforts may render the test result uninterpretable. (11)(12) There may be useful information gathered from less than optimal studies. At least 3 trials should be performed, in which the highest FEV_1 and FVC values should not differ by more than 5%. (11)(12)

PREDICTED NORMAL VALUES

Reference values for spirometry are derived from studies of specific populations of healthy people. One example is that of National Health and Nutrition Examination Survey III. (13) Popular pediatric predicted sets are those of Hsu et al, (14) Polgar and Promadhat, (15) and Wang et al. (16) The age of the patient should be represented in the reference set used. Other factors that are important are sex, height, weight, and race/ethnicity. Because height plays a big role in determining the predicted values, an accurate height measurement should be performed at the time of spirometry. For nonambulatory patients, arm span can be used to estimate height. (17)(18) Commercial spirometers usually will include a choice of reference values, such that the user can choose one to match the specific patient population being tested.

NORMAL SPIROMETRY

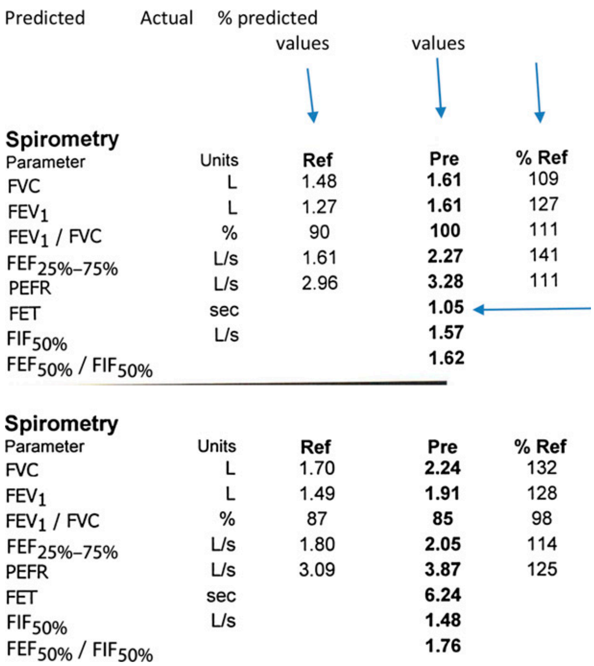
In general, parameters above 80% of predicted (and an FEV_1/FVC ratio >80%) are considered normal results (Figure 1). (19)

FLOW-VOLUME LOOPS

A plot of flow vs volume is generated during spirometry and should be examined to determine the acceptability of the test and to give a preliminary idea of the interpretative pattern. A normal flow-volume loop will show the vital capacity on the

TABLE 1. **The Planned Asthma Visit**

• All patients >4 years old receive the Asthma Control Test
• Spirometry is performed with bronchodilator at the initial visit to establish diagnosis (or without bronchodilator for follow-up)
• Practitioner reviews results
• Asthma action plan is reviewed or created
• Follow-up appointment 1–6 months based on severity and/or control
• Office visit code 99214
• Simple spirometry code 94010
• Spirometry with bronchodilator code 94060



Predicted Actual % predicted
values values

Spirometry

Parameter	Units	Ref	Pre	% Ref
FVC	L	1.48	**1.61**	109
FEV_1	L	1.27	**1.61**	127
FEV_1 / FVC	%	90	**100**	111
$FEF_{25\%–75\%}$	L/s	1.61	**2.27**	141
PEFR	L/s	2.96	**3.28**	111
FET	sec		**1.05**	
$FIF_{50\%}$	L/s		**1.57**	
$FEF_{50\%}$ / $FIF_{50\%}$			**1.62**	

Spirometry

Parameter	Units	Ref	Pre	% Ref
FVC	L	1.70	**2.24**	132
FEV_1	L	1.49	**1.91**	128
FEV_1 / FVC	%	87	**85**	98
$FEF_{25\%–75\%}$	L/s	1.80	**2.05**	114
PEFR	L/s	3.09	**3.87**	125
FET	sec		**6.24**	
$FIF_{50\%}$	L/s		**1.48**	
$FEF_{50\%}$ / $FIF_{50\%}$			**1.76**	

Figure 1. Two examples of normal spirometry results. The upper has a short exhalation time (horizontal arrows) such as would be seen in a younger child. The lower has exhalation time longer than 6 seconds, such as would be expected in an older child or adult. $FEF_{25\%–75}$ indicates expiratory volume between 25% and 75% of vital capacity; $FEF_{50\%}$ indicates forced expiratory flow at 50%; FET, forced expiratory time; FEV_1, forced expiratory volume in 1 second; $FIF_{50\%}$, forced inspiratory flow at 50%; FVC, forced vital capacity; and PEFR, peak expiratory flow rate.

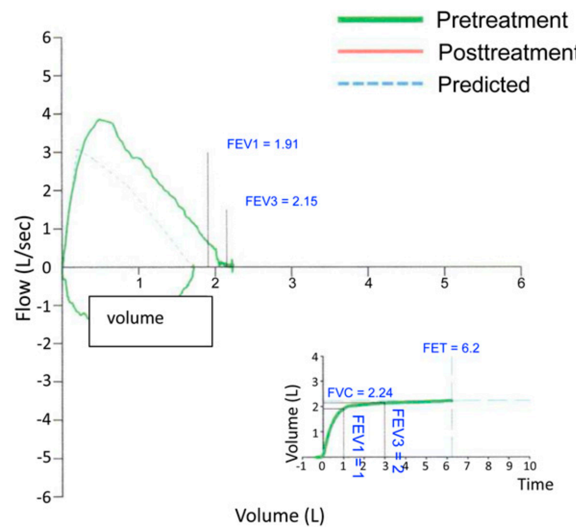


Figure 2. Normal expiratory flow-volume loop (upper left) and volume time curve (lower right). Note the vital capacity is the linear distance on the x-axis. The volume-time curve shows an exhalation time of 6.24 seconds and an end-expiratory plateau, indicating complete exhalation. FET indicates forced expiratory time; FEV_1, forced expiratory volume in 1 second; FEV_3, forced expiratory volume in 3 seconds; and FVC, forced vital capacity.

horizontal axis and the peak flow on the vertical axis. The slope of the curve is an indication of the expiratory flows (Figure 2). (FEV_1 is not calculated from the flow-volume loop but can be determined from the volume-time curve.)

COACHING THE PATIENT

To improve reliability, the patient should take a few tidal breaths, inhale deeply and completely, and then blow rapidly and as long as possible, until there is zero flow, before inhaling the next breath. Computer-operated systems often have child-friendly incentives, such as a rocket ship, blowing out candles on a cake, and other animations that encourage continued exhalation efforts. The person doing the coaching has to be child-friendly and patient, yet has to have the technical expertise to operate the equipment while coaching the child. It is essential that the child have a tight seal on the mouthpiece, with the tongue under and not in the mouthpiece. Nose clips are used to prevent loss of air through the nose. The instructions should be "take in a deep breath and blow, blow, blow…" until the test is completed. Three reproducible trials are recommended, and up to 8 can be performed and stored on most software. The 2 largest FVC results should be within 150 mL of each other (within 100 mL for FVC <1 L). In some children, only 1 or 2 acceptable tests may be performed. For younger children, a parent may be needed during the test, but older patients should be able to perform the testing without parental input.

The flow-volume loop must be examined to ensure the validity of the test. It should rapidly rise to a sharp peak, have a smooth expiratory curve, and not terminate until full exhalation has been achieved. Cough, sudden termination of exhalation, and uneven expiratory effort are common errors seen in flow-volume loops. The Centers for Disease Control and Prevention has a web-based poster that illustrates normal flow-volume loops and those with common errors. (21) This poster (available at http://cdc.gov/niosh/docs/2011-135/pdfs/2011-135.pdf) can be printed and hung in the testing room, if desired (see Appendix B).

OBSTRUCTIVE LUNG DISEASE

Obstructive lung disease is characterized by decreased airflow, as measured by FEV_1 and $FEF_{25\%–75\%}$. The FVC is usually normal in mild disease, but with more severe disease, air trapping causes the vital capacity to decrease as the residual volume increases. It is possible for both FVC and FEV_1 to be normal, but if the ratio of FEV_1/FVC ratio is less than 80%, obstructive lung disease is present. (19) When the FEV_1 and $FEF_{25\%–75\%}$ are diminished, the flow-volume loop will have a scooped out appearance because of lower flow rates (Figures 3 and 4). Obstructive lung conditions other than asthma include chronic obstructive pulmonary disease, bronchiolitis, bronchiectasis, cystic fibrosis, congestive heart failure, sarcoidosis, or pulmonary embolism.

BRONCHODILATOR RESPONSE

In general, an increase in FEV_1 of greater than 12% (for low lung volumes, minimum change of 200 mL) and/or an increase in $FEF_{25\%-75\%}$ of greater than 20% is considered a significant positive response to a bronchodilator (Figure 3). (19)

RESTRICTIVE LUNG DISEASE

The defining characteristic of restrictive lung disease is decreased lung volume. The FVC decreases, whereas the measures of airflow, FEV_1, and $FEF_{25\%-75\%}$ are preserved. The key to recognition may lie in the ratio of FEV_1/FVC, which increases as the denominator (the FVC) decreases. In addition, severe restriction will make all parameters decrease, except the FEV_1/FVC ratio. The flow-volume loop retains its normal shape but becomes smaller as the vital capacity diminishes (Figures 5 and 6). Examples of restrictive lung diseases include muscular dystrophy, scoliosis, pulmonary fibrosis, and other types of pneumoconiosis.

VOCAL CORD DYSFUNCTION SYNDROME

Vocal cord dysfunction is a condition in which a patient attempts to inhale against partially or totally closed vocal cords, resulting in inspiratory obstruction. This results in flattening of the lower (inspiratory) limb of the flow-volume loop (Figure 7). Vocal cord dysfunction is often misdiagnosed as asthma, with which it is often comorbid. (22) It occurs as the result of paradoxical closure of the vocal cords on inspiration, which produces stridor, dyspnea, and noises that are often misinterpreted as wheezing.

Spirometry

Parameter	Units	Ref	Pre	% Ref	Post	% Ref	% Chg
FVC	L	2.13	**2.68**	126	**2.63**	123	-2
FEV_1	L	1.83	**1.99**	109	**2.28**	125	15
FEV_1 / FVC	%	86	**74**	86	**87**	101	18
$FEF_{25\%-75\%}$	L/s	2.07	**1.22**	59	**2.62**	127	115
PEFR	L/s	3.87	**5.81**	150	**6.03**	156	4
FET	sec		**5.81**		**7.25**		25
$FIF_{50\%}$	L/s		**4.55**		**2.08**		-54
$FEF_{50\%}$ / $FIF_{50\%}$			**0.37**		**1.82**		392

Figure 3. Obstructive lung disease, as indicated by low forced expiratory volume in 1 second (FEV_1)/forced vital capacity (FVC) ratio, despite normal values for the FVC and FEV_1, and low forced expiratory flow between 25% and 75% of vital capacity ($FEF_{25\%-75\%}$). The improvement in FEV_1 and $FEF_{25\%-75\%}$ after bronchodilator is significant. $FEF_{50\%}$ indicates forced expiratory flow at 50%; FET, forced expiratory time; $FIF_{50\%}$, forced inspiratory flow at 50%; and PEFR, peak expiratory flow rate.

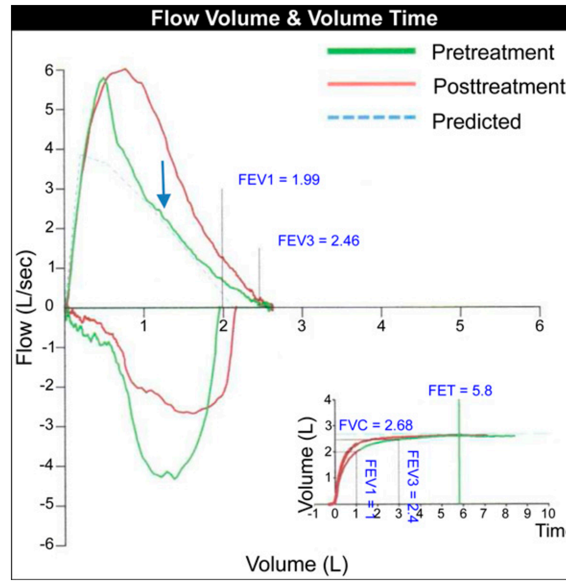


Figure 4. Flow-volume curve for the results seen in Figure 3. Obstructive lung disease is present, as indicated by the scooped-out appearance of the expiratory curve (arrow indicates decreased airflow). Postbronchodilator curve reveals improved airflow with similar vital capacity. FET indicates forced expiratory time; FEV_1, forced expiratory volume in 1 second; FEV_3, forced expiratory volume in 3 seconds; and FVC, forced vital capacity.

COMPARISON OF TEST RESULTS

The usual convention for defining significant change between test results is to have measured volumes (FVC and FEV_1) change by more than 10% and $FEF_{25\%-75\%}$ by 20% to 30% (Figure 8). (19)

EVIDENCE-BASED SUMMARY

On the basis of some research and consensus, the 2007 NHLBI expert panel asthma guidelines recommend

Spirometry

Parameter	Units	Ref	Pre	% Ref
FVC	L	2.47	**0.62**	25
FEV_1	L	2.14	**0.49**	23
FEV_1 / FVC	%	85	**79**	93
$FEF_{25\%-75\%}$	L/s	3.31	**0.49**	15
PEFR	L/s	5.74	**1.27**	22
FET	sec		**9.38**	
$FIF_{50\%}$	L/s		**0.58**	
$FEF_{50\%}$ / $FIF_{50\%}$			**1.74**	

Figure 5. Restrictive lung disease is present. The forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) are low, but the FEV_1/FVC ratio is relatively preserved (box), which is the key to recognition for restrictive patterns. $FEF_{25\%-75\%}$ indicates expiratory flow between 25% and 75% of vital capacity; $FEF_{50\%}$, forced expiratory flow at 50%; FET, forced expiratory time; $FIF_{50\%}$, forced inspiratory flow at 50%; and PEFR, peak expiratory flow rate.

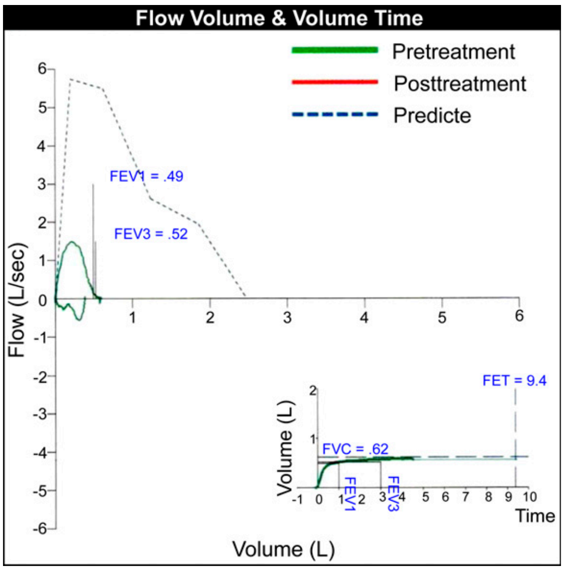


Figure 6. Flow-volume curve in restrictive lung disease. The shape is normal (ie, not scooped out), but the size of the curve is very small, indicating decreased volume, which is the key to recognition for restrictive flow-volume loops. FET indicates forced expiratory time; FEV_1, forced expiratory volume in 1 second; FEV_3, forced expiratory volume in 3 seconds; and FVC, forced vital capacity.

Test History

Parameter	Units	Today 2/27/2014	5/29/2013
FVC	L	**4.58**	4.14
FEV_1	L	**4.15**	3.84
FEV_1 / FVC	%	**91**	93
$FEF_{25\%–75\%}$	L/s	**5.00**	5.32

Figure 8. Comparison of testing over time. The forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) indicate improvement from the first test to the second. $FEF_{25\%–75\%}$ indicates expiratory flow between 25% and 75% of vital capacity.

spirometry be part of routine asthma diagnosis and monitoring of therapy. (3) Just as hypertension is managed by measuring blood pressure regularly and diabetes is managed by checking blood glucose levels, so should lung diseases should be managed by performing spirometry in capable patients. Multiple research studies have provided evidence indicating that with currently available equipment and proper training, primary care offices can and should be able to offer spirometry to test patients with pulmonary symptoms. (7)(8)

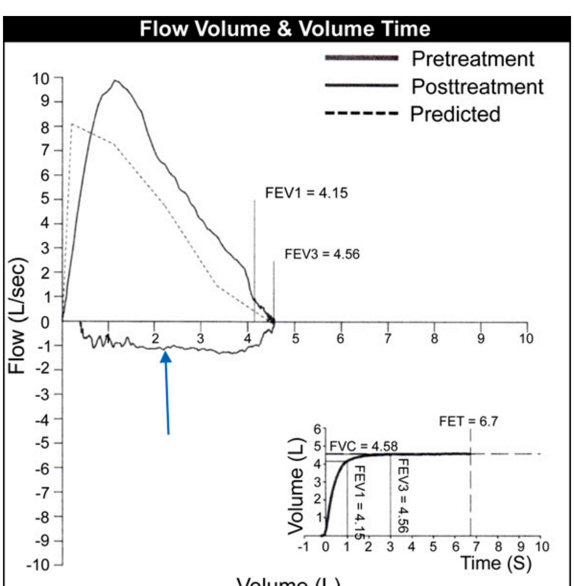


Figure 7. Extrathoracic obstruction. The expiratory flow-volume curve appears normal in shape, but the inspiratory loop is very flat (arrow), indicating upper airway obstruction, such as is seen with vocal cord dysfunction. FET indicates forced expiratory time; FEV_1, forced expiratory volume in 1 second; FEV_3, forced expiratory volume in 3 seconds; and FVC, forced vital capacity.

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PIR Quiz

1. An 8-year-old presents to your office with a prolonged cough. You perform spirometry, and his initial forced expiratory volume in 1 second (FEV_1) is 1.30 L. After use of an inhaled bronchodilator, which of the following FEV_1 results represents the most significant positive response?
   A. 1.15 L.
   B. 1.25 L.
   C. 1.35 L.
   D. 1.40 L.
   E. 1.55 L.
2. Which of the following spirometry measurements reflects the flow from the smaller airways?
   A. Forced expiratory flow between 25% and 75% of vital capacity ($FEF_{25\%–75\%}$).
   B. Forced expiratory time (FET).
   C. FEV_1.
   D. FEV_1/forced vital capacity (FVC) ratio.
   E. FVC.
3. To gather the most useful and accurate information from spirometry testing, the child should perform the test at least 3 times and:
   A. The child should exhale slowly and steadily for a minimum of 10 seconds.
   B. The child should exhale through the nose and mouth forcefully for 1 to 2 seconds.
   C. The child should hyperventilate for 30 to 45 seconds before testing.
   D. The FEV_1 should increase by at least 12% each time.
   E. The highest FEV_1 and FVC values should not differ by more than 5%.
4. When interpreting spirometry results, the most likely condition causing diminished FEV_1 and $FEF_{25\%–75\%}$ and resulting in a flow-volume loop with a scooped-out appearance is:
   A. Asthma.
   B. Pneumoconiosis.
   C. Pulmonary fibrosis.
   D. Scoliosis.
   E. Vocal cord dysfunction.
5. Which of the following clinical conditions is most likely to cause the following findings on spirometry: a small but normal-shaped flow-volume loop and demonstration of increased ratio of FEV_1/FVC?
   A. Asthma.
   B. Bronchiectasis.
   C. Chronic obstructive pulmonary disease.
   D. Muscular dystrophy.
   E. Sarcoidosis.

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Appendix A

Key Points for Asthma Guideline Implementation

GOALS OF THERAPY	**Reduce Impairment** • Prevent chronic and troublesome symptoms • Minimize the need to use SABA for relief of asthma symptoms to ≤2 days/week • Maintain (near) normal pulmonary function • Maintain normal activity levels **Reduce Risk** • Prevent recurrent exacerbations • Provide optimal pharmacotherapy with minimal or no adverse effects • Minimize the need for ED visits or hospitalizations **Optimize Health and Function** • Provide initial and ongoing education to patient and family • Educate patient and family to recognize and avoid triggers • Partner with patient and family to identify treatment goals and achieve well-controlled asthma that allows patient to fully and safely participate in activities (eg, physical education, recess, sports, etc) • Maintain patient's and family's satisfaction with asthma care
ASSESSMENT	• Classify asthma severity and level of asthma control • Identify precipitating and exacerbating factors (ie, asthma triggers, including those in the home, school, and child care settings) • Identify comorbid medical conditions that may adversely affect asthma management • Periodically inspect medications, inhaler, and spacer to verify appropriate type • Regularly assess the patient's and family's knowledge and skills for self-management, including medication administration and inhaler and spacer technique
VISIT FREQUENCY	**If asthma is not well controlled:** Visits at 2- to 6-week intervals are recommended **If asthma is well controlled:** Visits at 3- to 6-month intervals are recommended to monitor how well asthma control is maintained and to adjust medications as necessary
PATIENT AND FAMILY EDUCATION	Incorporate the following into every clinical encounter: **Use a written asthma action plan to share when and how to:** • Take daily actions to control asthma • Adjust medication in response to signs of worsening asthma **Knowledge** • Basic facts about asthma • Role of medications **Skills** • Take medications correctly, use appropriate type of inhaler and spacer with proper technique • Identify and avoid asthma triggers • Self-monitor level of asthma control • Recognize early signs and symptoms of worsening asthma • Seek medical care as appropriate • Communicate asthma information to school, child care center, and other caregivers
OBTAIN SUBSPECIALIST CONSULTATION IF:	(see Table 1 on the following page) • 0-4 years and Step 3 care or higher is required (may consider consultation at Step 2) • 5 years or older and Step 4 care or higher is required (may consider consultation at Step 3) • Difficulty in achieving or maintaining asthma control

Information adapted from Texas Children's Health Plan's "Key Points for Asthma Guideline Implementation"

Acronyms
SABA = Short acting beta agonist
LABA = Long acting beta agonist
ICS = Inhaled corticosteroid
OCS = Oral corticosteroid
ED = emergency department

MEDICAL HOME CHAPTER CHAMPIONS PROGRAM ON ASTHMA

Appendix A Continued.

Table 1: Stepwise approach to managing asthma

Steps	Preferred treatment
Step 1	SABA prn
Step 2	Low dose ICS
Step 3	0-4 years: Medium dose ICS + subspecialist referral ≥5 years: Low dose ICS + LABA or medium dose ICS
Step 4	Medium dose ICS + LABA or montelukast + subspecialist referral
Step 5	High dose ICS + LABA or montelukast + subspecialist referral
Step 6	High dose ICS + LABA or montelukast + OCS + subspecialist referral

Notes
- The stepwise approach is meant to assist—not replace—clinical decision making.
- Before step up, review adherence, inhaler technique, environmental control and comorbid conditions.
- If clear benefit is not observed within 4-6 weeks and/or technique and adherence is not satisfactory, consider adjusting therapy and/or alternative diagnoses.

Acronyms
SABA = Short acting beta agonist
LABA = Long acting beta agonist
ICS = Inhaled corticosteroid
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Table 2: Classifying asthma severity and initiating therapy

Components of severity		Intermittent	Persistent		
			Mild	Moderate	Severe
Impairment	Symptoms	≤2 days/week	>2 days/week	Daily	Throughout the day
	Nighttime awakenings	0 (≤4 years) ≤2x/month (≥5 years)	1-2x/month (≤4 years) 3-4x/month (≥5 years)	3-4x/month (≤4 years) >1x/week (≥5 years)	>1x/week (≤4 years) Often 7x/week (≥5 years)
	SABA use for symptoms	≤2 days/week	>2 days/week	Daily	Several times per day
	Limitation of normal activity	None	Minor	Some	Extreme
	Lung function *	FEV1>80% FEV1/FVC>85% (5-11 years) FEV1/FVC normal (≥12 years)	FEV1>80% FEV1/FVC>85% (5-11 years) FEV1/FVC normal (≥12 years)	FEV1>60% FEV1/FVC>75% (5-11 years) FEV1/FVC reduced by 5% (≥12 years)	FEV1<60% FEV1/FVC<75% (5-11 years) FEV1/FVC reduced >5% (≥12 years)
Risk	Exacerbations requiring OCS	0-1/year	≥2/6 months (0-4 years) ** ≥2/year (≥5 years)		
Recommended step for initiating therapy ***		Step 1	Step 2	Step 3	Step 3 (≤4 years) Step 3 or 4 (5-11 years) Step 4 or 5 (≥12 years)

Table 3: Assessing asthma control and adjusting therapy

Components of control		Well controlled	Not well controlled	Very poorly controlled
Impairment	Symptoms	≤2 days/week	>2 days/week or (if ≤11 years) multiple times ≤2 days/week	Throughout the day
	Nighttime awakenings	≤1x/month (if ≤12 years) ≤2x/month (if >12 years)	≥2x/month (if ≤12 years) 1-3x/week (if >12 years)	≥2x/week (if ≤12 years) ≥4x/week (if >12 years)
	Interference with normal activity	None	Some limitation	Extremely limited
	SABA use for symptoms	≤2 days/week	>2 days/week	Several times per day
	Lung function *	FEV1>80% FEV1/FVC>80%	FEV1 60-80% FEV1/FVC 75-80%	FEV1<60% FEV1/FVC<75%
Risk	Exacerbations requiring OCS	0-1x/year	2-3x/year (if 0-4 years) ≥2x/year (if ≥5 years)	≥3x/year (if 0-4 years) ≥2x/year (if ≥5 years)
	Reduction in lung growth	Requires long-term follow-up		
	Treatment related to adverse effects	Medication side effects do not correlate with specific levels of control, but should be considered in overall assessment of risk.		
Recommended action for treatment ****		Consider step down if well controlled for ≥3 months.	Step up 1 step. Re-evaluate in 2-6 weeks.	Consider short course oral corticosteroid. Step up 1-2 steps. Re-evaluate in 2 weeks.

* Some individuals with smaller lungs in relation to their height (such as a thin individual with narrow A-P diameter to their chest) may normally have FEV1<80% and/or FEV1/FVC<85%. Lung function measures should be correlated with clinical assessment of asthma severity.

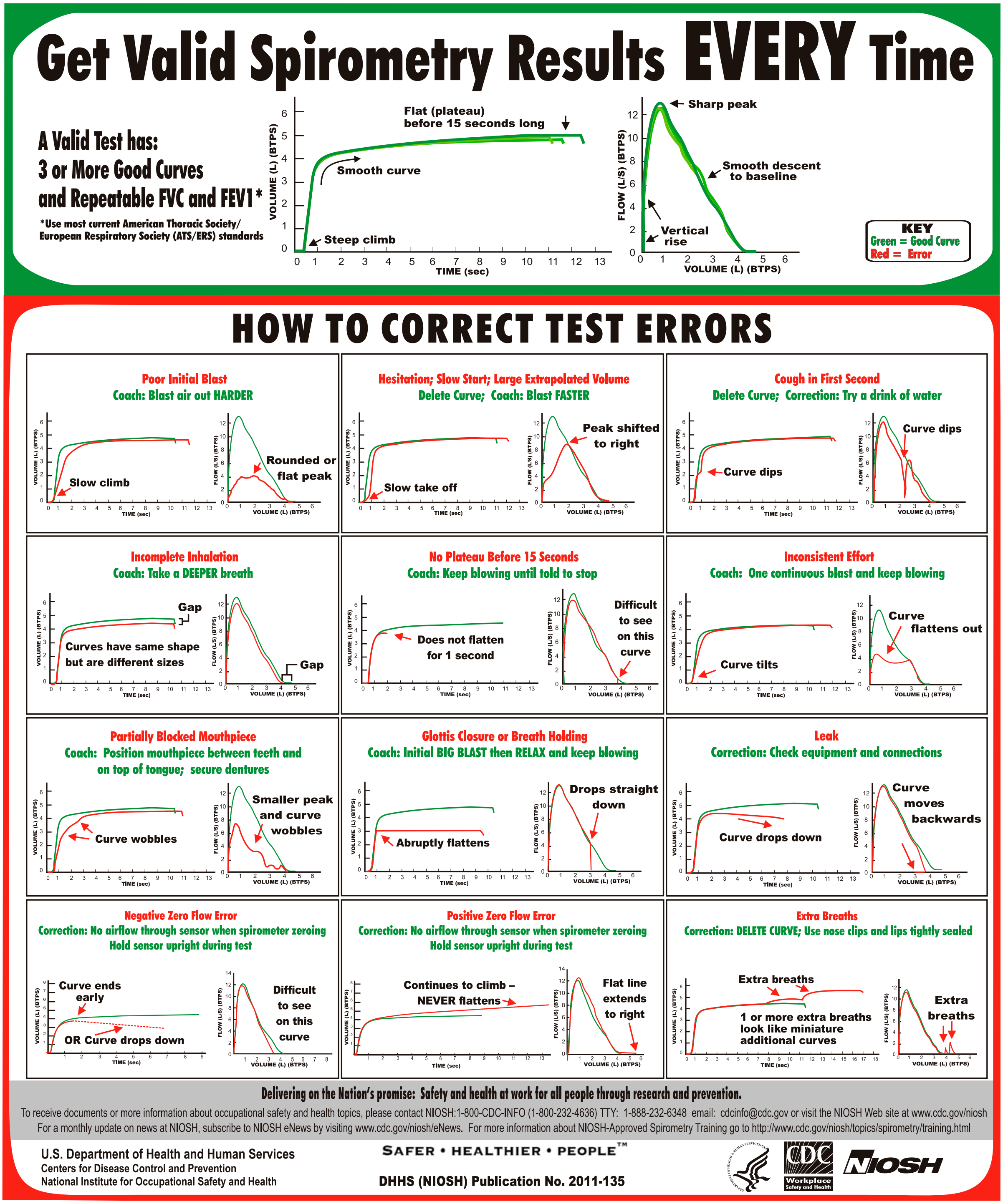
** For 0-4 years, ≥4 wheezing episodes per year each lasting >1 day and risk factors for persistent asthma meets risk criteria for persistent asthma.

*** For initial therapy of moderate or severe persistent asthma that is poorly controlled, consider a short course of OCS.

**** Recommended guidelines

Spring 2013 (DOCSN/AAP)

Appendix B



Get Valid Spirometry Results EVERY Time
A Valid Test has:
3 or More Good Curves
and Repeatable FVC and FEV1*
*Use most current American Thoracic Society/ European Respiratory Society (ATS/ERS) standards
VOLUME (L) (BTPS)
TIME (sec)
Flat (plateau) before 15 seconds long
Smooth curve
Steep climb
FLOW (L/S) (BTPS)
VOLUME (L) (BTPS)
Sharp peak
Smooth descent to baseline
Vertical rise
KEY
Green = Good Curve
Red = Error
HOW TO CORRECT TEST ERRORS
Poor Initial Blast
Coach: Blast air out HARDER
Slow climb
Rounded or flat peak
Hesitation; Slow Start; Large Extrapolated Volume
Delete Curve; Coach: Blast FASTER
Slow take off
Peak shifted to right
Cough in First Second
Delete Curve; Correction: Try a drink of water
Curve dips
Curve dips
Incomplete Inhalation
Coach: Take a DEEPER breath
Gap
Curves have same shape but are different sizes
Gap
No Plateau Before 15 Seconds
Coach: Keep blowing until told to stop
Does not flatten for 1 second
Difficult to see on this curve
Inconsistent Effort
Coach: One continuous blast and keep blowing
Curve tilts
Curve flattens out
Partially Blocked Mouthpiece
Coach: Position mouthpiece between teeth and on top of tongue; secure dentures
Curve wobbles
Smaller peak and curve wobbles
Glottis Closure or Breath Holding
Coach: Initial BIG BLAST then RELAX and keep blowing
Abruptly flattens
Drops straight down
Leak
Correction: Check equipment and connections
Curve drops down
Curve moves backwards
Negative Zero Flow Error
Correction: No airflow through sensor when spirometer zeroing
Hold sensor upright during test
Curve ends early
OR Curve drops down
Difficult to see on this curve
Positive Zero Flow Error
Correction: No airflow through sensor when spirometer zeroing
Hold sensor upright during test
Continues to climb – NEVER flattens
Flat line extends to right
Extra Breaths
Correction: DELETE CURVE; Use nose clips and lips tightly sealed
Extra breaths
1 or more extra breaths look like miniature additional curves
Extra breaths
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Pediatrics in Review
An Official Journal of the American Academy of Pediatrics

Spirometry for the Primary Care Pediatrician

Robert Kaslovsky and Matthew Sadof

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