

# New spirometry interpretation algorithm

Primary Care Respiratory Alliance of Canada approach

Anthony D. D'Urzo MD MSc CCFP FCFP Itamar Tamari MD CCFP FCFP Jacques Bouchard MD  
Reuven Jhirad MD CCFP FCFP Pieter Jugovic MD MSc CCFP

### Clinical question

Is there a need for a new spirometry interpretation algorithm that contains decision-making criteria consistent with current guidelines on asthma<sup>1</sup> and chronic obstructive pulmonary disease (COPD)<sup>2</sup> diagnosis?

### Using spirometry to distinguish between COPD and asthma

Office spirometry provides valuable information about the relationship between flow and volume in relation to lung function and can be useful for diagnosing common conditions such as asthma and COPD.<sup>1,2</sup> Mechanical abnormalities of the respiratory system can be classified as either *obstructive* (flow-related) or *restrictive* (volume-related) ventilatory defects; obstructive defects are much more common in clinical practice. The relationship between flow and volume is described well by the ratio of the forced expiratory volume in 1 second (FEV<sub>1</sub>) to the forced vital capacity (FVC). These measurements can be easily obtained with a simple office spirometer during a forced expiratory maneuver. The ratio of FEV<sub>1</sub> to FVC can be useful to identify obstructive, restrictive, and combined (obstructive-restrictive) defects, but it is important to recognize that total lung capacity, a more sophisticated measurement (and not the FVC), is the best measurement to confirm a diagnosis of pulmonary restriction.<sup>3</sup> Traditionally an FEV<sub>1</sub>-FVC ratio below 0.70 has been used to define a pure obstructive defect if the FVC is within normal limits. Measurement of post-bronchodilator FEV<sub>1</sub>-FVC ratio is necessary to differentiate between an acute or persistent obstructive defect and to evaluate whether reductions in the FVC are the result of hyperinflation (air trapping, where the FVC improves after bronchodilator challenge) or are related to problems in pulmonary compliance; in the latter case, the FEV<sub>1</sub>-FVC ratio is often normal or elevated and spirometric indices often change very little after bronchodilator challenge.<sup>3</sup>

Current guidelines<sup>2</sup> indicate that a spirometric diagnosis of COPD must include an FEV<sub>1</sub>-FVC ratio that is reduced consistently below 0.70 after bronchodilation. An interpretation algorithm currently endorsed by the Ontario Thoracic Society<sup>4</sup> lacks these diagnostic criteria in its decision tree; consequently, a spirometric diagnosis of COPD cannot be confirmed. Criteria for a spirometric diagnosis of asthma include an improvement in FEV<sub>1</sub> of 12% (preferably 15%) and 200 mL after bronchodilator challenge.<sup>1</sup> Although the FEV<sub>1</sub>-FVC ratio might be normal in many patients with asthma (on the basis of a normal FVC value), this does not exclude the possibility that FEV<sub>1</sub> will improve substantially with bronchodilator challenge (see case 1 below). In a currently available algorithm,<sup>4</sup> the finding of a normal FEV<sub>1</sub>-FVC result does not prompt further testing after bronchodilator challenge. Differences between asthma and COPD and how the FEV<sub>1</sub>-FVC ratio can change after bronchodilator challenge are heavily influenced by different pathophysiologic mechanisms; in asthma the FEV<sub>1</sub>-FVC ratio results can be normal or can return to normal after bronchodilator challenge at any given time. In COPD, FEV<sub>1</sub> is influenced

#### BOTTOM LINE

- An algorithm commonly promoted in primary care is limited by its focus on using changes in forced expiratory volume in 1 second (FEV<sub>1</sub>) to distinguish asthma from chronic obstructive pulmonary disease (COPD). The new algorithm consolidates current spirometric concepts that are consistent with both asthma and COPD guidelines.
- The new algorithm facilitates spirometric diagnosis of COPD by focusing on postbronchodilator FEV<sub>1</sub>-forced vital capacity ratios, and does not use changes in FEV<sub>1</sub> after bronchodilation to separate asthma from COPD.

#### POINTS SAILLANTS

- Un algorithme communément recommandé en soins de première ligne est limité parce qu'il est axé sur l'utilisation des changements dans le volume expiratoire maximal en 1 seconde (VEMS) pour distinguer l'asthme de la maladie pulmonaire obstructive chronique (MPOC). Le nouvel algorithme intègre les concepts spirométriques actuels qui concordent avec les guides de pratique concernant l'asthme ainsi que les MPOC.
- Le nouvel algorithme facilite le diagnostic spirométrique de la MPOC en ciblant les ratios VEMS par rapport à la capacité vitale forcée après usage d'un bronchodilatateur et n'utilise pas les changements dans le VEMS après bronchodilatation pour distinguer l'asthme de la MPOC.

This article has been peer reviewed.

Cet article a fait l'objet d'une révision par des pairs.

Can Fam Physician 2011;57:1148-52

by permanent architectural changes, such as loss of alveolar attachments, that predispose airways to collapse more readily.<sup>2</sup> Further, reductions in lung elastic recoil often reduce FEV<sub>1</sub> in COPD.<sup>2</sup> These latter changes in COPD result in a persistent reduction in FEV<sub>1</sub>. By contrast, asthmatic airway obstruction is determined to a great extent by factors related to bronchospasm, airway inflammation, and mucous plugs; these changes can improve either spontaneously or in response to therapy.<sup>1</sup> It is common for the FEV<sub>1</sub> value to be normal in many patients with asthma, particularly when the disease is well controlled.

### Spirometric overlap between asthma and COPD can cause confusion

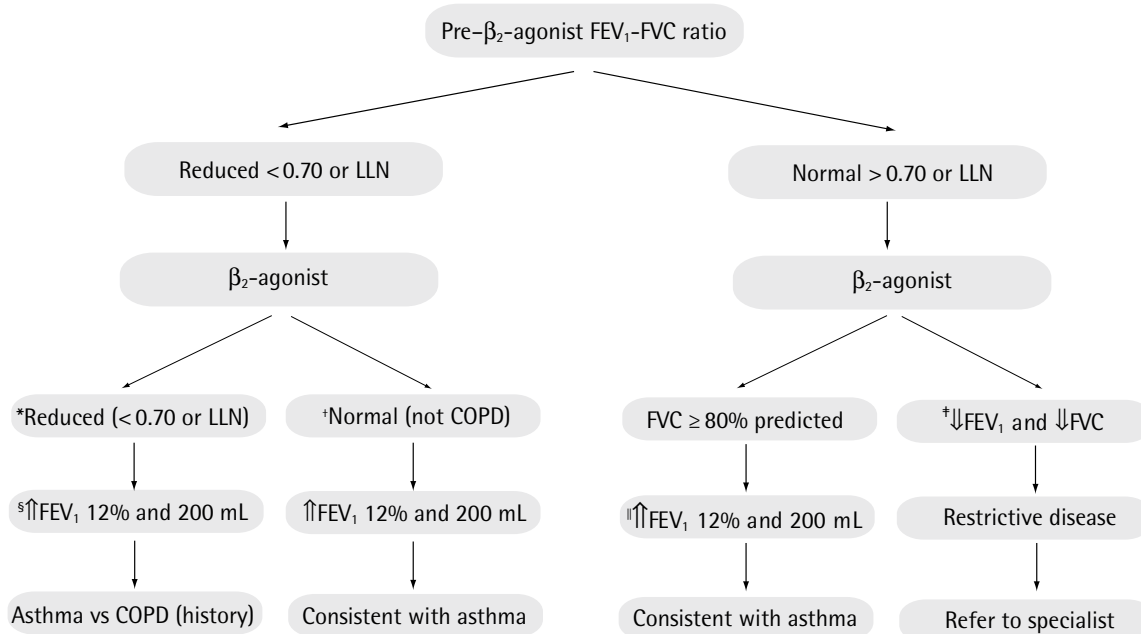
Traditionally, COPD has been described as a disease characterized by fixed airflow obstruction because in many patients FEV<sub>1</sub> values improve little after bronchodilator challenge. Current guidelines<sup>2</sup> on diagnosis and management describe COPD as a condition that is

partially reversible because some patients exhibit substantial improvements in FEV<sub>1</sub> (despite an FEV<sub>1</sub>-FVC ratio that remains below 0.70) that compare in magnitude to what is observed in some asthma patients. In fact, Tashkin et al<sup>5</sup> have shown that about 54% of a large COPD cohort (N=5756) exhibited an improvement in FEV<sub>1</sub> values >12% and 200 mL, while about 65% of patients had FEV<sub>1</sub> increases >15%. This substantial overlap in FEV<sub>1</sub> reversibility between asthma and COPD underscores an important limitation of using this measurement to distinguish between asthma and COPD; instead we need to formulate a clinical diagnosis based on physical examination, history, and spirometric data. An algorithm currently promoted in primary care<sup>4</sup> is limited by its focus on using changes in FEV<sub>1</sub> to distinguish asthma from COPD.

### New spirometry interpretation algorithm

Given the limitations of the currently available algorithm,<sup>4</sup> members of the Primary Care Respiratory

**Figure 1. Spirometry interpretation algorithm from the Primary Care Respiratory Alliance of Canada**



COPD—chronic obstructive pulmonary disease, FEV<sub>1</sub>—maximal volume of air exhaled after a maximal inhalation in the first second of a forced exhalation, FVC—maximal volume of air exhaled after inhalation during forced exhalation, LLN—lower limit of normal.

\*FVC < 80% predicted—perform full pulmonary function tests to rule out hyperinflation vs combined obstructive and restrictive defect.

†FVC ≥ 80% predicted.

‡FEV<sub>1</sub> and FVC < 80% predicted.

§The % change is calculated as (FEV<sub>1</sub> postbronchodilator - FEV<sub>1</sub> prebronchodilator) / FEV<sub>1</sub> prebronchodilator.

¶Lack of change in FEV<sub>1</sub> is not diagnostic; referral for methacholine challenge recommended.

Alliance of Canada have proposed a new algorithm (Figure 1) where spirometric diagnostic criteria for both asthma and COPD are included and consistent with current guidelines.<sup>1,2</sup> The new algorithm focuses on the FEV<sub>1</sub>-FVC ratio before and after bronchodilator challenge as a means of identifying acute or persistent airflow obstruction. This approach helps to exclude a diagnosis of COPD quickly if the FEV<sub>1</sub>-FVC ratio returns to normal after bronchodilator challenge. The new algorithm also includes bronchodilator challenge in patients with a normal baseline FEV<sub>1</sub>-FVC ratio, recognizing the variable nature of asthma and the possibility that a normal FEV<sub>1</sub> result could improve greatly in response to bronchodilator challenge. The new algorithm also addresses the subject of reversibility as it is described in both asthma and COPD guidelines.<sup>1,2</sup> Current COPD guidelines underscore that airflow limitation is only partially reversible because the FEV<sub>1</sub>-FVC ratio does not return to normal despite improvements

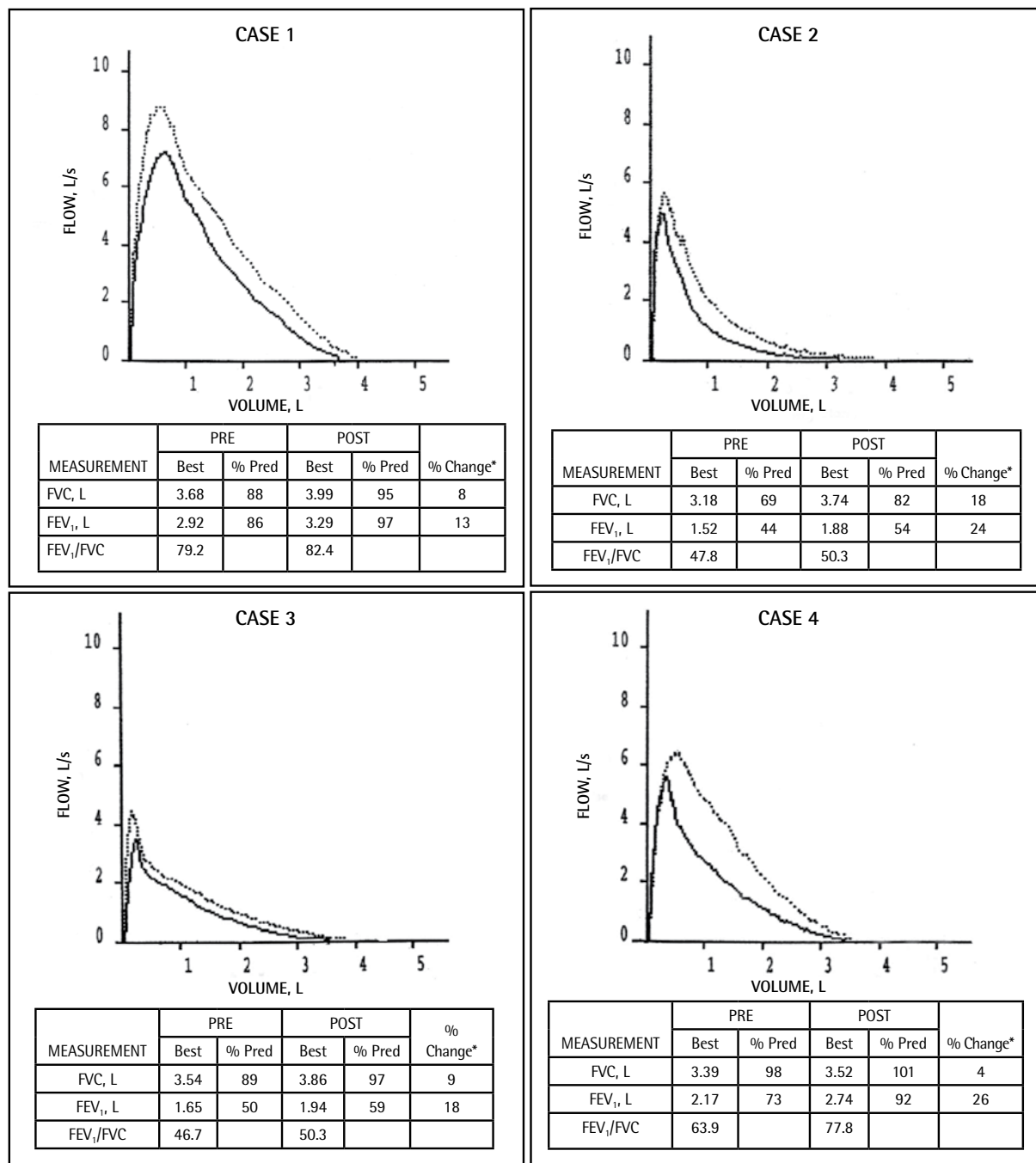
in airway calibre (airflow) in many COPD patients after bronchodilator challenge; improvements in FEV<sub>1</sub> can also be observed in asthma patients. The new algorithm does not focus on changes in FEV<sub>1</sub> after bronchodilator challenge as a means of separating asthma from COPD because of the substantial spirometric overlap between these 2 conditions. Because a clinical diagnosis of asthma and COPD cannot be confirmed with spirometric data alone, Table 1<sup>6</sup> highlights historical and physical examination data that can help differentiate asthma from COPD. This table is included because one of the decision nodes in the new algorithm leads the reader to consider asthma versus COPD. It is important to consider conditions other than asthma and COPD in patients who present with respiratory complaints, including wheezing. It should be noted that this algorithm can be used for both adults and children, although some school-aged children might not meet international criteria for spirometry.<sup>7</sup>

**Table 1. Differences between asthma and COPD**

FACTORS	ASTHMA	COPD
Influence of smoking on disease process	<ul style="list-style-type: none"> <li>no direct relationship but can adversely influence disease control</li> <li>some asthma cases can develop into COPD after many years of smoking</li> </ul>	<ul style="list-style-type: none"> <li>direct relationship</li> </ul>
Inflammation (airways)	<ul style="list-style-type: none"> <li>eosinophilic</li> </ul>	<ul style="list-style-type: none"> <li>neutrophilic</li> </ul>
Reversibility of airway obstruction	<ul style="list-style-type: none"> <li>hallmark of asthma</li> <li>airway obstruction is episodic and completely reversible in mild disease</li> <li>in chronic severe disease, only partial reversibility seen with either bronchodilator or anti-inflammatory therapy</li> </ul>	<ul style="list-style-type: none"> <li>airway obstruction is persistent with little or no response to bronchodilator or anti-inflammatory therapy in most patients</li> </ul>
Age	<ul style="list-style-type: none"> <li>onset often in early life: asthma is the most common chronic disease in children</li> </ul>	<ul style="list-style-type: none"> <li>onset in later life; often in sixth decade</li> </ul>
Course with time	<ul style="list-style-type: none"> <li>episodic</li> </ul>	<ul style="list-style-type: none"> <li>slow, insidious decline in lung function leading to disability</li> </ul>
Role of atopy	<ul style="list-style-type: none"> <li>most asthma patients are allergic to airborne allergens such as dust mite, animal dander, pollens, molds</li> </ul>	<ul style="list-style-type: none"> <li>uncommon</li> </ul>
Symptoms	<ul style="list-style-type: none"> <li>episodic</li> </ul>	<ul style="list-style-type: none"> <li>slowly progressive</li> </ul>
Signs (other)	<ul style="list-style-type: none"> <li>cor pulmonale never seen</li> </ul>	<ul style="list-style-type: none"> <li>cor pulmonale when disease is severe</li> </ul>
Diffusing capacity	<ul style="list-style-type: none"> <li>normal in pure asthma</li> </ul>	<ul style="list-style-type: none"> <li>often decreased; more so with emphysema</li> </ul>
Hypoxemia	<ul style="list-style-type: none"> <li>not common but can be present in severe exacerbations</li> </ul>	<ul style="list-style-type: none"> <li>often present and chronic in advanced disease</li> </ul>
Bronchodilator response	<ul style="list-style-type: none"> <li>often marked improvements in FEV<sub>1</sub> into the normal range</li> </ul>	<ul style="list-style-type: none"> <li>can be present, but FEV<sub>1</sub> typically remains chronically reduced</li> </ul>
Response to corticosteroids	<ul style="list-style-type: none"> <li>often dramatic</li> </ul>	<ul style="list-style-type: none"> <li>most patients do not respond in a clinically meaningful way</li> </ul>
Chest x-ray scan	<ul style="list-style-type: none"> <li>often normal or findings of hyperinflation, which are episodic</li> </ul>	<ul style="list-style-type: none"> <li>can be normal</li> <li>increased bronchial markings</li> <li>chronic hyperinflation (emphysema)</li> <li>useful to rule out other conditions</li> </ul>

COPD—chronic obstructive pulmonary disease, FEV<sub>1</sub>—maximal volume of air exhaled after a maximal inhalation in the first second of a forced exhalation. Reprinted with permission from D'Urzo.<sup>6</sup>

**Figure 2. Spirometric data for case examples**



FEV<sub>1</sub>—maximal volume of air exhaled after a maximal inhalation in the first second of a forced exhalation, FVC—maximal volume of air exhaled after inhalation during forced exhalation, % Pred—percent of predicted normal value, Pre—pre-bronchodilator value, Post—postbronchodilator value.

\*Percent change =  $\frac{(FEV_1 \text{ Post} - FEV_1 \text{ Pre})}{FEV_1 \text{ Pre}}$

### Application to clinical practice


Four brief spirometry cases, all meeting American Thoracic Society<sup>8</sup> criteria for acceptability and reproducibility, highlight how the new algorithm could be used as a stand-alone document to interpret spirometric data.

**Case 1.** The prebronchodilator and postbronchodilator FEV<sub>1</sub>-FVC ratios are 0.79 and 0.82, respectively (**Figure 2**), while the FEV<sub>1</sub> improves from 2.92 to 3.29 L after bronchodilation (increase of 370 mL and 13%). The new algorithm indicates that these data are consistent with asthma given the normal FEV<sub>1</sub>-FVC ratio and improvements in FEV<sub>1</sub> after bronchodilation. The patient in this case was a 45-year-old man who had never been a smoker. He had intermittent bouts of shortness of breath and chest tightness and normal results from cardiovascular workup. His response to asthma therapy was favourable.

**Case 2.** The prebronchodilator and postbronchodilator FEV<sub>1</sub>-FVC ratios are 0.48 and 0.50, respectively (**Figure 2**). The prebronchodilator and postbronchodilator FEV<sub>1</sub> results are 1.52 and 1.88 L, respectively (increase of 360 mL and 24%). The new algorithm recognizes the reduction in FEV<sub>1</sub>-FVC ratio before bronchodilator use, but the postbronchodilator FEV<sub>1</sub>-FVC ratio is evaluated to determine whether there is a combined defect of obstruction and restriction or hyperinflation. Given that the FVC increased to more than 80% of the predicted value with bronchodilation, it becomes clear that hyperinflation contributed to the reduced prebronchodilator FVC measurement. Because the postbronchodilator FEV<sub>1</sub>-FVC ratio remains below 0.70 and the FEV<sub>1</sub> reversibility criterion is met,<sup>1</sup> the clinician is led to differentiate asthma from COPD using historical data (**Table 1**).<sup>6</sup> The patient in this case is a 73-year-old man with a 40-pack-year smoking history, no allergies to environmental factors, and a history of progressive shortness of breath over the past 10 years. The medical history and family history were otherwise unremarkable for asthma risk factors. The historical and spirometric data in this case are consistent with a clinical diagnosis of COPD.

**Case 3.** The prebronchodilator and postbronchodilator FEV<sub>1</sub>-FVC ratios are 0.47 and 0.50, respectively (**Figure 2**). The prebronchodilator and postbronchodilator FEV<sub>1</sub> values are 1.65 and 1.94 L, respectively (increase of 290 mL and 18%). The new algorithm recognizes the reduced FEV<sub>1</sub>-FVC ratio and the reversibility in FEV<sub>1</sub> after bronchodilation and guides the clinician to differentiate asthma from COPD on the basis of historical factors as well (**Table 1**).<sup>6</sup> The patient in this case is a 36-year-old woman who has never been a smoker. She has numerous environmental allergies and has severe asthma that is well controlled on maintenance therapy. Cases 2 and 3 highlight the spirometric overlap between

asthma and COPD and the limitations of using FEV<sub>1</sub> reversibility to help distinguish asthma from COPD.

**Case 4.** The prebronchodilator and postbronchodilator FEV<sub>1</sub>-FVC ratios are 0.64 and 0.78, respectively (**Figure 2**). The prebronchodilator and postbronchodilator FEV<sub>1</sub> values are 2.17 and 2.74 L, respectively (increase of 570 mL and 26%). The new algorithm quickly excludes a spirometric diagnosis of COPD on the basis of the normal postbronchodilator FEV<sub>1</sub>-FVC value, and the increase in FEV<sub>1</sub> would be consistent with a spirometric diagnosis of asthma. This case underscores the importance of using the postbronchodilator FEV<sub>1</sub>-FVC ratio to exclude COPD. The patient in this case is a 19-year-old boy with a history of childhood asthma and β<sub>2</sub>-agonist use increasing over several months. In the new algorithm, the central focus on postbronchodilator FEV<sub>1</sub>-FVC ratio will allow the person interpreting spirometric data to quickly exclude a spirometric diagnosis of COPD in many patients if the ratio returns to normal. In such patients, improvement in FEV<sub>1</sub> (increase of 12% and 200 mL)<sup>1</sup> is used to establish a spirometric diagnosis of asthma. This approach minimizes the risk of disease misclassification. Because spirometry can be used only to identify and differentiate between obstructive and restrictive ventilatory defects, historical and physical examination data are essential for establishing a clinical diagnosis (**Table 1**).<sup>6</sup> This process can be quite rewarding for clinicians who are comfortable with interpretation of spirometry data. 

**Dr D'Urzo** is Associate Professor, and **Drs Jhirad** and **Tamari** are Lecturers, all in the Department of Family and Community Medicine at the University of Toronto in Ontario. **Dr Bouchard** is Associate Professor of Clinical Medicine at Laval University, Head of the Department of Medicine at Centre hospitalier de la Malbaie, and a family physician in La Malbaie, Que. **Dr Jugovic** is Lead Hospitalist in the Department of Family Practice at Toronto East General Hospital. All authors are members of the Primary Care Working Group of the Primary Care Respiratory Alliance of Canada.

#### Acknowledgment

We thank **Deborah D'Urzo**, **Devra D'Urzo**, and **Vasant Solanki** for their valuable assistance in preparing this manuscript.

#### Competing interests

None declared

#### References

1. National Heart, Lung, and Blood Institute National Asthma Education and Prevention Program. *Expert panel report 3: guidelines for the diagnosis and management of asthma*. NIH Publications No. 07-4051. Washington, DC: US Department of Health and Human Services; 2007.
2. O'Donnell DE, Aaron S, Bourbeau J, Hernandez P, Marciniuk D, Hodder R, et al. Canadian Thoracic Society recommendations for management of chronic obstructive pulmonary disease-2007 update. *Can Respir J* 2007;14(Suppl B):5B-32B.
3. Wanger J, Clausen JL, Coates A, Pedersen OF, Brusasco V, Burgos F, et al. Standardization of the measurement of lung volumes. *Eur Respir J* 2005;26(3):511-22.
4. *Spirometry in primary care* [CD-ROM]. Toronto, ON: The Lung Association; 2007.
5. Tashkin DP, Celli B, Decramer M, Liu D, Burkhart D, Cassino C, et al. Bronchodilator responsiveness in patients with COPD. *Eur Respir J* 2008;31(4):742-50. Epub 2008 Feb 6.
6. D'Urzo AD. Differentiating asthma from COPD in primary care. *Ont Thorax Rev* 2001;13(1):1-7.
7. Arets HG, Brackel HJ, van der Ent CK. Forced expiratory manoeuvres in children: do they meet ATS and ERS criteria for spirometry? *Eur Respir J* 2001;18(4):655-60.
8. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. *Eur Respir J* 2005;26(2):319-38.