Small Airways Obstruction Syndrome*

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Study objectives: To clarify the significance of a functional lung pattern characterized by a decreased vital capacity (VC) and an increased residual volume (RV), but with a normal FEV1/VC ratio.

Setting: A university teaching hospital.

Subjects: Patients with bronchial asthma, pulmonary emphysema, and small airways disease, and older subjects.

Measurements: Measurements of static and dynamic lung volumes, diffusing capacity of the lung for carbon monoxide (as measured by the single-breath method), nitrogen slope of the alveolar plateau, and closing volume (as measured by the single-breath O2 test).

Conclusion: A functional pattern characterized by a decreased VC and FEV1 and increased RV, but with a normal FEV1/VC ratio and total lung capacity, reflects an obstructive impairment of small airways.

Key words: bronchial asthma; FEV1; obstructive syndrome; pulmonary emphysema; residual volume; small airways; spirometry

Abbreviations: RV = residual volume; TLC = total lung capacity; VC = vital capacity

In practice, a reduced FEV1 to vital capacity (VC) ratio is used as a criterion for the presence of airflow limitation. In its statement on lung function testing, the American Thoracic Society mentioned that “FEV1/VC should be the primary guide for distinguishing obstructive from nonobstructive patterns.” The severity of airway obstruction is assessed by the FEV1 in relation to reference values.1,2 A decreased FEV1/VC ratio or FEV1 is not indicative of the localization of airway obstruction. Some authors consider that a decrease of maximum expiratory flow rates, especially near the end of the VC, reflects obstruction of small airways.3 This is not generally accepted. However, several tests such as frequency dependence of compliance, closing volume (as measured by the single-breath O2 test), and the nitrogen slope of the alveolar plateau, are considered to indicate the presence of small airways obstruction, based on comparative anatomofunctional studies.4 These tests have enjoyed popularity in the seventies but are not used in everyday practice, because they require expensive measurements and operator expertise. They are available only in research centers.5

In this paper, we discuss a particular functional pattern observed by us and others: a decrease of VC and FEV1, an increase of both residual volume (RV) and RV/total lung capacity (TLC) ratio, a normal FEV1/VC ratio and TLC, and therefore, according to current criteria, the absence of both obstructive and restrictive defects.

In a recent volume on lung function tests published in the United States, the authors write that “a low FEV1 with a normal ratio usually indicates a restrictive process.... However, a subset of patients with a low FEV1 and normal FEV1/VC ratio also had a normal TLC, which rules out significant [my emphasis] restriction. This is termed a ‘nonspecific ventilatory limitation’ and is attributed to relatively quiescent asthma.” In another well-known book on the same topic, no mention is made of this pattern.2 The American Thoracic Society workshop on lung function testing states that “A reduced VC without evidence of expired slowing is a nonspecific find-
However, there was controversy among participants of this workshop about using the term 'restrictive' when VC is low. The majority thought it was acceptable to interpret the finding as indicating a ‘restrictive type of ventilatory impairment’ or a ‘restrictive ventilatory defect’ while recognizing that it does not necessarily indicate restrictive lung disease. Others argued the interpretation should be descriptive only, i.e., simply noted as ‘reduced VC’ or ‘nonobstructive defect,’ and call for further testing, including lung volumes, to clarify its nature. Two years later, the European Respiratory Society in its official statement mentioned that the ‘VC...may be diminished by both restrictive and obstructive ventilatory defects; in the latter case it is due to an increase in RV due to (premature) airways closure (gas trapping) and airflow limitation at low lung volumes leading to incomplete lung emptying.’ However, (they continue) in small airways disease the RV is increased with no change in TLC; accordingly the VC is reduced (with a proportional decrease in FEV1). Hence the VC alone is of little use in discriminating between restrictive, obstructive and mixed ventilatory defects.

The central phenomenon of this pattern is the increase in RV and in the RV/TLC ratio, a feature otherwise known as air trapping or hyperinflation. In normal young people the expiratory limit is set by the chest wall, which limits further emptying of the lungs. In elderly subjects, however, secondary to progressive loss of elastic recoil (and a suggested increased tendency of airway closure), most of the small airways are closed at RV, and this factor sets the limit of expiration. Pathologic conditions associated with intrinsic and extrinsic obstruction of small airways will also lead to an increase in RV. In the former situation, due to narrowing or obliteration of small airways, airways start to close at a higher transpulmonary pressure, always close at a higher transpulmonary pressure, always start to close at a higher transpulmonary pressure, and therefore indicate small airways obstruction. In the latter situation, due to loss of elastic recoil, most of the small airways are closed at RV, and this factor sets the limit of expiration. Factors determining RV are still incompletely understood, although factors determining RV are progressive loss of elastic recoil (and a suggested increased tendency of airway closure). In small airways disease, due to narrowing or obliteration of small airways, airways start to close at a higher transpulmonary pressure, leading to incomplete lung emptying.

Table 1—Age and Lung Function in Patients with Small Airways Obstructive Syndrome

<table>
<thead>
<tr>
<th>Patient</th>
<th>Diagnosis</th>
<th>Age, yr</th>
<th>Gender</th>
<th>TLC, ± %</th>
<th>VC, ± %</th>
<th>RV, ± %</th>
<th>RV/TLC, ± %</th>
<th>FEV1, ± %</th>
<th>FEV1/VC, ± %</th>
<th>Dlco, ± %</th>
<th>∆N2, ± %</th>
<th>CV, ± %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bronchial asthma</td>
<td>43</td>
<td>F</td>
<td>89</td>
<td>66</td>
<td>161</td>
<td>183</td>
<td>44</td>
<td>66</td>
<td>100</td>
<td>75</td>
<td>95</td>
</tr>
<tr>
<td>2</td>
<td>Pulmonary emphysema</td>
<td>65</td>
<td>F</td>
<td>96</td>
<td>66</td>
<td>168</td>
<td>173</td>
<td>52</td>
<td>62</td>
<td>94.5</td>
<td>66</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>Old subject</td>
<td>72</td>
<td>M</td>
<td>91</td>
<td>72</td>
<td>131</td>
<td>143</td>
<td>46</td>
<td>67</td>
<td>94</td>
<td>68</td>
<td>101</td>
</tr>
<tr>
<td>4</td>
<td>Small airways disease</td>
<td>60</td>
<td>M</td>
<td>93</td>
<td>74</td>
<td>140</td>
<td>150</td>
<td>43</td>
<td>72</td>
<td>97</td>
<td>69</td>
<td>75</td>
</tr>
</tbody>
</table>

* RV = residual volume, as measured by the dilution method; Dlco = diffusing capacity of the lung for carbon monoxide, as measured by the single-breath method (predicted values from Frans et al21); ∆N2 = nitrogen slope of the alveolar plateau, as measured by the single-breath O2 test (predicted values from Knudson et al22); CV = closing volume, as measured by the single-breath O2 test (predicted values from Buist and Ross23); F = female; M = male.

† Expressed as percent predicted (from Jouassent20).
‡ Expressed as actual values.
Rubin and Bruderman\textsuperscript{16} have reported seven patients complaining of dyspnea during exercise with no abnormal physical findings or chest radiograph abnormalities present. All patients showed an increased RV and functional residual capacity. FEV\textsubscript{1}/FVC ratio, total lung resistance, and maximal expiratory flow rate were all within normal limits. However, lung compliance was frequency dependent, which, according to the authors, indicated airway obstruction of the peripheral bronchioles. Subsequently, Guerry-Force et al\textsuperscript{17} have reported on nine cases with small airways disease established by lung biopsy. TLC and FEV\textsubscript{1}/FVC ratio were within normal limits, but FVC was decreased and RV was increased. These findings are similar, though less severe, to those reported previously by Macklem et al.\textsuperscript{18}

This particular functional pattern, called by some authors a “nonspecific finding” or a “nonspecific ventilatory limitation” appears to be an obstructive syndrome localized at the small airways level. It is observed in early emphysema, small airways disease, asymptomatic bronchial asthma, and in older people (Table 1). How frequent is this pattern? Because it is observed in such different conditions, it cannot be a rarity. Aaron et al\textsuperscript{19} recently studied consecutive adult white patients who had undergone both spirometry and lung volume measurements. When the analysis was confined to patients with a low FVC and normal (or above normal) FEV\textsubscript{1}/FVC ratio, only 153 of 264 patients (58\%) had a true restrictive syndrome, ie, a decreased TLC. One hundred eleven other patients (42\%) had a normal TLC (ie, the functional syndrome we are discussing).

I suggest that this pattern should be called “small airways obstruction syndrome.” A spiographic pattern characterized by a decreased VC and FEV\textsubscript{1} but with a normal FEV\textsubscript{1}/VC ratio calls for measurement of RV (if it is not done routinely). In the absence of such a measurement, this pattern would be ignored and called, as we have seen, a restrictive or a nonspecific defect. An obstructive syndrome would thus be overlooked.

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**REFERENCES**