Assessment of the Portable COPD-6 Device for Detecting Obstructive Airway Diseases

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ABSTRACT

Objectives: To evaluate the agreement and the association with FEV1, FEV6 and FEV1/FEV6 measured with the Vitalograph-COPD-6 portable device and the FEV1, FVC and FEV1/FVC by conventional spirometry, and to analyse the validity of this device to detect obstruction.

Methodology: A cross-sectional, descriptive, prospective study, that included 180 subjects. A conventional spirometry and a spirometry with the Vitalograph-COPD-6 were sequentially performed on them. The agreement was analysed [kappa index and interclass correlation coefficient (ICC)], as well as the association [Pearson correlation coefficient (r)], area under the ROC curve (AUC) of the FEV1/FEV6 in detecting obstruction, and the sensitivity, specificity, predictive values (PPV and NPV), and probability ratios (PR+ and PR−) of the different FEV1/FEV6 cut-off points in the detection of obstruction.

Results: The prevalence of obstruction was 47 %. The kappa index was 0.59 when an FEV1/FEV6 < cut-off point of < 0.7 was used. The ICC and the r between the FEV1 measured by the two instruments, FEV6 and FEV1/FEV6 measured by the Vitalograph-COPD-6 and the FVC and FEV1/FVC determined by the spirometer were all greater than 0.92. The ROC AUC was 0.97. To detect obstruction, if the cut-off point of FEV1/FEV6 (for COPD-6) was < 0.70, the sensitivity, specificity, PPV, NPV, CR+ and CR− were, 58 %, 100 %, 100 %, 73 %, ∞ and 0.42, respectively. For a cut-off point of < 0.8, they were 96 %, 76 %, 78 %, 96 %, 3.8 and 0.05, respectively.

Conclusions: The portable Vitalograph-COPD-6 device is precise for the detection of airway obstruction. The best sensitivity/specificity of FEV1/FEV6 was obtained with cut-off points greater than 0.7.

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FEV1, in order to define the obstructive disorder. Hence, we have proper determination of the forced vital capacity (FVC), an essential staff perform spirometric manoeuvres is the difficulty in obtaining a of the most common and significant problems when non-expert proposed and demonstrated that the forced expiratory volume in six seconds (FEV6), a more easily determined parameter, may be an acceptable substitute for FVC in the diagnosis of obstruction in adults. 9 To fight this under-diagnosis, it is essential to carry out a screening of patients at risk of COPD in non-specialised settings such as Primary Care Centers. In order to do this, it is essential that spirometry is performed routinely and with appropriate quality at that care level. However, current evidence shows that this is far from reality. 10-13 One of the latest devices sold in Spain is the Vitalograph COPD-6 meter. Besides simplifying the spirometry procedure, FEV1 has the practical advantage of reducing variability, which helps improve its diagnostic capacity. On the other hand, however, conventional spirometers would be required for determining FEV6, which are not always available at all care-giving settings and would require a certain amount of maintenance and financial investment. This has led to the recent design and commercialisation of various portable electronic devices that allow for a quick reading of FEV1, FEV6 and the FEV1/FEV6 ratio, which makes them especially useful in COPD screening in non-specialised care centres. However, their diagnostic accuracy compared with conventional spirometers has scarcely been studied. One of the latest devices sold in Spain is the Vitalograph COPD-6 (model number 4000, Vitalograph Ltd., Ireland) (fig. 1), which according to its manufacturers is very easy to use and accurate enough to reliably determine FEV1, FEV6, and the FEV1/FEV6 ratio. To date there have been no published articles analysing its validity and safety in clinical practice as a screening tool for obstructive diseases.

The aims of this study were: firstly, to evaluate the agreement and relationship between the parameters obtained by the Vitalograph COPD-6 and those measured by a conventional spirometer; and secondly, to determine the sensitivity, specificity, predictive values and probability ratios for this device in detecting obstructions, using a conventional spirometer as a gold standard.

Material and Methods

This was a prospective, descriptive transversal study. The included patients were recruited from those who attended our pulmonary function laboratory for functional respiratory tests over two consecutive months. Each of them was asked for their consent to participate in our study, which was approved by the ethics committee of our centre. For the final analysis, we excluded those subjects who, after a brief explanation, did not understand the technique or were unable to perform proper and reproducible spirometric manoeuvres.

The following was performed on all patients: a) a conventional spirometry measuring FEV1, FVC and the FEV1/FVC ratio; b) a measurement of FEV1, FEV6, and FEV1/FEV6 ratio using the portable Vitalograph COPD-6 meter.

Conventional spirometries were performed using two different spirometers, both Masterlab model pneumotachographs that incorporate reference values recommended by the Spanish Society of Pneumology and Thoracic Surgery (Spanish acronym SEPAR).

COPD-6 (fig. 1) is a small portable electronic device measuring 11.3 cm high, 6.3 cm wide and 4.5 cm thick and weighs 55 g. It is powered by two disposable batteries, is easy to use and can measure FEV1, FEV6, and the FEV1/FEV6 ratio. It also includes the reference values of the ECCS (European Community for Coal and Steel),

Introduction

Obstructive pathologies of the airway, especially COPD and asthma, are highly prevalent, affecting 5-10% of the population. Despite their potential morbidity and mortality and the significant consumption of resources they entail, both diseases are under-diagnosed, with COPD rates reaching over 80%. COPD diagnosis is based on the detection of an airway obstruction that is largely irreversible in an adequate clinical/epidemiological context, making a forced spirometry procedure indispensable in this case. To fight this under-diagnosis, it is essential to carry out a screening of patients at risk of COPD in non-specialised settings such as Primary Care Centers. In order to do this, it is essential that spirometry is performed routinely and with appropriate quality at that care level. However, current evidence shows that this is far from reality. One of the most common and significant problems when non-expert staff perform spirometric manoeuvres is the difficulty in obtaining a proper determination of the forced vital capacity (FVC), an essential parameter, along with the forced expiratory volume in one second (FEV1), in order to define the obstructive disorder. Hence, we have proposed and demonstrated that the forced expiratory volume in six seconds (FEV6), a more easily determined parameter, may be an acceptable substitute for FVC in the diagnosis of obstruction in adults.

Figure 1. Portable COPD-6 device (Vitalograph). CI indicates confidence interval.
which it also shows for each parameter the percentage of the value obtained versus its theoretical value. It has a large easy-to-read display and a comfortable design that allows it to be easily held by the patient. The requirement for calibration is not included in the instructions for this portable COPD-6 device. Before taking any readings with this device, the user must enter some patient data including age, size and sex. The manoeuvre that must be performed is similar to that of a spirometry; the patient must take a deep breath, then insert the mouthpiece into their mouth and then exhale vigorously and continuously for six seconds. When that time is reached, the device emits a beep to indicate that the patient can stop the manoeuvre. COPD-6 also incorporates a flowmeter that detects errors such as the premature ending of the manoeuvre or coughing, by displaying an exclamation mark on-screen and emitting a longer beep. Another feature of this device is that it indicates with an arrow whether there is an obstruction or not (indicating yes if the FEV$_1$/FEV$_6$ ratio is $< 0.7$), and displaying on a color scale the degree of the obstruction according to the classification recommended in the GOLD guidelines.

Measurements with both devices were performed by trained staff and were carried out in a standardised manner. Spirometer measurements were performed according to the SEPAR guidelines with previous calibration daily using the three-litre syringe and adjusted for temperature, humidity and atmospheric pressure. With the COPD-6 portable meter, three manoeuvres were performed for each patient (as described above), which had to meet criteria for acceptability and reproducibility, selecting the best values in each case for each parameter. To further simplify the procedure, no nose clips were used in the expiratory manoeuvres performed with the COPD-6.

Upon random selection, one group was measured with COPD-6 prior to conventional spirometry and other groups were measured using COPD-6 after conventional spirometry.

**Statistical Analysis**

The qualitative variables were expressed by absolute values and percentages, and the quantitative variables by mean and standard deviation (shown as mean ± standard deviation). To express the differences between the different parameters studied the average of the difference and its 95% CI were used. The comparison of quantitative variables was performed by applying the Student’s t-test for paired samples. A value of $p$ less than or equal to 0.05 was considered statistically significant. To evaluate the agreement between both devices for detecting obstructions (FEV$_1$/FVC and FEV$_1$/FEV$_6$ $< 0.7$), the value recommended by the current guidelines for spirometry and from the manufactures of the COPD-6), the kappa index was used as the qualitative variable. The agreement and relationship between the values of FEV$_1$ measured by both devices, the FEV$_1$/FVC quotient and the FVC (measured using conventional spirometry) and FEV$_1$/FEV$_6$ and FEV$_6$ (measured using the COPD-6) were analysed by calculating the intraclass correlation coefficient (ICC) and the Pearson correlation coefficient ($r$) respectively, and were represented graphically using Bland and Altman graphs and correlation graphs.

The validity and specificity of the COPD-6 in detecting obstructions was determined using standard formulas, and the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive probability quotient (+PQ) and negative probability quotient (–PQ) were calculated. We also estimated the area under the ROC (Receiver-Operating Characteristic) curve of the FEV$_1$/FEV$_6$ ratio (measured with the COPD-6) in the discrimination of the obstruction, using the FEV$_1$/FVC $< 0.7$ quotient obtained with conventional spirometry as the gold standard.

The sample size calculation was performed after an interim analysis of the first 40 cases included, estimating that the COPD-6 could provide a 90% sensitivity and a 80% specificity in detecting obstructions, a 40% prevalence, and an alpha error of 5%. To achieve an estimated accuracy of 8%, the necessary sample size needed to be 162 subjects.

**Results**

Of a total 180 subjects, 162 were included in the study and 18 were excluded (four for not understanding the technique and 14 because of unacceptable or non-reproducible spirometric manoeuvres). Of these, 95 (59%) were men. The mean age was 56 (16) years. Thirty (18%) patients were diagnosed with COPD, 32 (20%) with asthma, 40 (25%) with other pathologies (bronchiectasis, tuberculosis sequela, mixed pathologies, miscellaneous) and 60 (37%) had no specific diagnosis. Seventy-six (47%) of the cases showed an obstructive pattern in spirometry, with a mean FEV$_1$ of 66.2% (22.2). In 57 cases (75%), FEV$_1$, measured by spirometry was $> 50\%$ (compared to the baseline value) and 19 (25%) had an FEV$_1 < 50\%$.

The absolute and percentage values of the different parameters measured with the spirometer and with the COPD-6 are shown in

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**Table 1**

<table>
<thead>
<tr>
<th>Spirometer</th>
<th>COPD-6</th>
<th>$p$</th>
<th>Spirometer–COPD-6 Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV$_1$</td>
<td>2,460 (996) ml</td>
<td>2,292 (957) ml</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FVC vs. FEV$_1$</td>
<td>3,516 (1,500) ml</td>
<td>3,031 (1,062) ml</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FEV$_1$/FVC vs. FEV$_1$/FEV$_6$</td>
<td>0.69 (0.13)</td>
<td>0.74 (0.12)</td>
<td>0.001</td>
</tr>
<tr>
<td>% FEV$_1$</td>
<td>81.3 (25)</td>
<td>80.5 (25)</td>
<td>0.11</td>
</tr>
<tr>
<td>% FVC vs. % FEV$_1$</td>
<td>87.4 (10)</td>
<td>88.4 (21)</td>
<td>0.36</td>
</tr>
</tbody>
</table>

CI indicates confidence interval.

*Median (standard deviation).

*SEPAR-recommended reference values.

*ECCS reference values.

*Median of the difference and 95% confidence interval of the median.

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The table also lists the average of the differences and their 95% CI. As can be seen, the absolute values of FEV\textsubscript{1} measured by conventional spirometers were significantly higher than the measurements by the COPD-6, with a 95% CI between 144-190 mL. The FVC value was also significantly higher than the FEV\textsubscript{1}, with a 95% CI between 442-528 mL. However, the FEV\textsubscript{1}/FVC value (measured with spirometry) was significantly lower than the FEV\textsubscript{1}/FEV\textsubscript{6} (measured with the COPD-6) and its 95% CI between 0.04-0.08. The baseline values used in the two devices were different (SEPAR for the spirometers and ECCS for the COPD-6) and the theoretical values of ECCS were significantly lower than those of SEPAR.\textsuperscript{17,18} For this reason, in the analysis of the percentage differences as a function of their

Figure 2. Bland and Altman graphs for a) the FEV\textsubscript{1} measured with the spirometer versus the COPD-6, b) the FVC measured with the spirometer versus the FEV\textsubscript{6} measured with the COPD-6, and c) the FEV\textsubscript{1}/FVC ratio measured with the spirometer versus the FEV\textsubscript{1}/FEV\textsubscript{6} measured with the COPD-6.

Figure 3. Correlation graphs for a) FEV\textsubscript{1} correlation with both devices, b) correlation between FVC by spirometry and FEV\textsubscript{6} by COPD-6, and c) correlation between FEV\textsubscript{1}/FVC ratio by spirometry and FEV\textsubscript{1}/FEV\textsubscript{6} ratio by COPD-6.
reference value, no significant differences were determined between the FEV₁ percentage determined by both devices and the FVC percentage (by spirometry) and the FEV₁ percentage (by COPD-6) compared to the theoretical values. The average differences were even lower than the unit.

A contingency table (table 2) was created for patients diagnosed with obstruction using spirometry and COPD-6, using a quotient < 0.7 in both cases (recommended by the manufacturers of the COPD-6). Of the 76 patients with FEV₁/FVC < 0.7 measured by spirometry, 32 (42.1 %) would not have been detected using this cutoff point for FEV₁/FEV₆. In this sense, the kappa index value was 0.59 (moderate).

The agreement and relationship between the various parameters analysed was: FEV₁ (spirometry) vs. FEV₁ (COPD-6): CCI = 0.98 (p < 0.001); r = 0.99 (p < 0.001); FVC (spirometry) vs. FEV₁ (COPD-6): CCI = 0.96 (p < 0.001), r = 0.97 (p < 0.001); FEV₁/FVC (spirometry) vs. FEV₁/FEV₆ (COPD-6): CCI = 0.93 (p < 0.001), r = 0.94 (p < 0.001); The Bland and Altman graphs are shown in figure 2 showing a tendency towards non-homogeneity in the differences in the three graphs. Instead, the difference is larger as the values of FEV₁ and FVC increase and larger when the FEV₁/FVC quotient is lower. However, the ICC values were excellent, which made the difference between the measurements of little importance in terms of the variation of the subjects.

The correlation graphs are shown in figure 3. Notice that the correlation is excellent for all parameters studied.

Figure 4 shows the ROC curve obtained from the FEV₁/FEV₆ ratio measured with COPD-6 for the detection of obstructions (considering FEV₁/FVC quotient < 0.7 as the reference pattern), with the ABC equal to 0.97 (95 % CI 0.95-0.99).

Table 3 shows the values for sensitivity, specificity, PPV, NPV, +PQ and –PQ for determining obstructions (using the value FEV₁/FVC < 0.7 obtained by spirometry as the gold standard) for the different cutoff points of the FEV₁/FEV₆ quotient measured by COPD-6.

**Discussion**

In order to carry out a proper screening of COPD and thereby face the problem of under-diagnosis, it is essential that spirometries are performed in primary care settings. This fact has been accepted and recommended by all scientific societies and is reflected in the National Health System’s recently published COPD National Strategy, which secondary goal is improving early diagnosis. However, we know that due to the lack of time, availability of spirometers, limited space, lack of education and training and poor motivation of many health professionals, this technique is little used at this level of care. Furthermore, in many centres that do perform spirometries, the quality of the studies are very much in doubt, mostly due to the difficulty in obtaining a proper FVC in spirometry manoeuvres. This parameter tends to have the most disagreement when comparing studies performed by personnel specialised in the technique with those performed by other practitioners. Furthermore, the manoeuvre that should be performed to achieve a proper reading of FVC is responsible for rare cases of dyspnea, dizziness and syncope reported with spirometry.

The substitution of this parameter with one that is easier to obtain, such as FEV₆, could improve implementation of spirometry. A recent meta-analysis that included 11 studies showed that the FEV₁/FEV₆ quotient reported an average sensitivity of 89 % and a specificity of 98 % when compared to the classic definition of obstruction based on the FEV₁/FVC value. This meta-analysis obtained an area under the ROC curve of FEV₁/FEV₆ for detecting obstructions of 0.97. However, the sensitivity of the reported FEV₁/FEV₆ quotient varied according to the various definitions for obstruction and the different cutoff points considered, without any agreement as to which should be considered. Another key element for enhancing COPD screening in non-specialised care settings may be the substitution of spirometry with easier-to-use portable devices. Three published studies in 2009 that combined these two aspects have demonstrated that the use of a small and simple electronic device such as the Piko-6

<table>
<thead>
<tr>
<th>FEV₁/FEV₆ (Vitalograph COPD-6)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>+PQ</th>
<th>–PQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.70</td>
<td>58</td>
<td>100</td>
<td>100</td>
<td>73</td>
<td>–</td>
<td>0.42</td>
</tr>
<tr>
<td>&lt; 0.71</td>
<td>66</td>
<td>100</td>
<td>100</td>
<td>77</td>
<td>–</td>
<td>0.34</td>
</tr>
<tr>
<td>&lt; 0.72</td>
<td>74</td>
<td>100</td>
<td>100</td>
<td>81</td>
<td>–</td>
<td>0.26</td>
</tr>
<tr>
<td>&lt; 0.73</td>
<td>83</td>
<td>98</td>
<td>97</td>
<td>87</td>
<td>35.6</td>
<td>0.18</td>
</tr>
<tr>
<td>&lt; 0.74</td>
<td>85</td>
<td>97</td>
<td>97</td>
<td>88</td>
<td>36.7</td>
<td>0.15</td>
</tr>
<tr>
<td>&lt; 0.75</td>
<td>87</td>
<td>96</td>
<td>97</td>
<td>88</td>
<td>36.0</td>
<td>0.14</td>
</tr>
<tr>
<td>&lt; 0.76</td>
<td>89</td>
<td>94</td>
<td>96</td>
<td>91</td>
<td>25.6</td>
<td>0.11</td>
</tr>
<tr>
<td>&lt; 0.77</td>
<td>90</td>
<td>92</td>
<td>92</td>
<td>91</td>
<td>12.7</td>
<td>0.12</td>
</tr>
<tr>
<td>&lt; 0.78</td>
<td>92</td>
<td>88</td>
<td>87</td>
<td>93</td>
<td>8.0</td>
<td>0.09</td>
</tr>
<tr>
<td>&lt; 0.79</td>
<td>96</td>
<td>83</td>
<td>84</td>
<td>95</td>
<td>5.7</td>
<td>0.06</td>
</tr>
<tr>
<td>&lt; 0.80</td>
<td>96</td>
<td>76</td>
<td>78</td>
<td>96</td>
<td>3.8</td>
<td>0.05</td>
</tr>
</tbody>
</table>

–PQ indicates negative probability quotient; +PQ, positive probability quotient; –, infinite; NPV, negative predictive value; PPV, positive predictive value.
accounts for the whole expiratory volume, while the FEV₁ only
where different parameters were obtained with spirometry.
definition of obstruction was significantly higher than that
depend on the equipment or on the measurement. This makes the
screening program. The patients had an FEV₁/FEV₆
group performed spirometries on 74 patients through a primary care
followed, more than 40 % of patients with spirometric obstruction
one was moderate. If the manufacturer’s recommendations are
the agreement using the same point for the two devices, only this
cutoff point that determines the obstruction cannot be 0.70 as
false positives which would establish the indication for a conventional spirometry study
to confirm the obstruction.

Conflict of interest
The authors confirm the lack of any conflict of interest with the
commercial companies mentioned in this study.

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