Performing slow vital capacity in older people with and without cognitive impairment — is it useful?

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Abstract

Background: most patients with moderate cognitive impairment are unable to perform forced spirometry. It has been suggested that slow vital capacity (SVC) is easier to perform than forced vital capacity (FVC) because it requires less understanding and co-ordination. We conducted a study to determine whether that assertion is correct.

Methods: we studied 83 inpatients, mean age 83 years (range 67–95, 51 female). They had measurements made of FVC, SVC and the Mini-Mental State Examination (MMSE). The spirometry was conducted using the European Respiratory Society/American Thoracic Society standards.

Results: of the 83 subjects, 38 were able to do both FVC and SVC and 32 were unable to do either. The overall concordance was 84%. Twelve were able to do SVC but not FVC (eight due to excessive cough, two due to weakness and two had an MMSE <24 with poor co-ordination). An inability to do neither FVC nor SVC was predicted by an MMSE <24/30 (P < 0.0001) with a sensitivity of 88% and specificity of 67%.

Conclusion: SVC is not a usable substitute for FVC for elderly patients with cognitive impairment but is of some utility for those who tend to cough. An MMSE <24/30 is predictive of inability to perform FVC and SVC.

Keywords: forced vital capacity, slow vital capacity, spirometry, elderly, cognitive impairment

Introduction

Spirometry provides objective evidence of airflow obstruction that is an important factor in making the diagnosis of conditions such as asthma and chronic obstructive airways disease (COPD), both of which are frequently encountered in old age. It also aids the diagnosis of restrictive lung diseases and allows clinicians to evaluate the response to treatment in patients with obstructive lung diseases. Many elderly patients are unable to give a clear history of their respiratory symptoms, so it can be argued that the supporting information gained from conducting spirometry is of enhanced value in such patients. The importance of this is emphasised in national guideline recommendations for the wider use of spirometry to detect COPD in older patients in both community and hospital settings [1]. Spirometry can be used together with other investigations, symptoms and physical signs to improve the diagnostic accuracy, assess disease severity and allow more rational treatment and management planning. Most elderly patients can perform forced spirometry to an adequate standard [2, 3]. However, it has been found that a proportion of older patients, particularly those above the age of 75 years, and some younger patients, are unable to perform the full forced spirometry manoeuvre to measure forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC). This ranged from 12% of community-dwelling older people [2] to 49% of elderly inpatients with indicators of frailty [3]. A number of studies showed that the most prominent barrier to adequate spirometry is cognitive impairment [2–6], though in some individuals uncontrollable coughing during the measurement of FVC was the identified problem, and some were apparently too weak or fatigable to reach adequate expiratory pressure repeatedly [3]. In earlier studies, we showed that the most frequent errors made by cognitively impaired patients were inconsistent effort, incomplete lung emptying, failure to breathe in to total lung capacity (TLC) before exhaling and breathing in before completion.
Performing SVC in older people with and without cognitive impairment

[3, 7]. There is a clear need for alternative methods to assess the lung volumes of patients unable to do forced spirometry. Methods such as whole body plethysmography and helium dilution volumetry require at least as much, or more, coordination than FVC and are not portable, so are not a practical solution to the problem. We hypothesised that measurement of slow vital capacity (SVC) might be more easily performed by patients who are unable to coordinate the apparently more demanding FVC manoeuvre. It can be argued that technician-assisted SVC should be achievable even in patients with cognitive impairment or inability to sustain high expiratory pressures. However, there have been no studies to establish whether this contention holds true in clinical practice. We therefore conducted a study to compare ability to perform FVC and SVC in elderly patients with and without cognitive impairment.

Methods

We performed a prospective observational study of 83 patients (51 female) with a mean age 83 years (range 67–95). All were inpatients receiving rehabilitation after an acute medical or surgical illness and had reached a stable clinical state at the time of recruitment. We studied subjects who were naïve to the procedure of spirometry in order to avoid the possibility that some patients with cognitive impairment might have retained a satisfactory technique from earlier in their clinical history. We recruited subjects who fulfilled the study criteria in chronological order of presentation, so the sample was quasi-random. The inclusion criteria were age 65 years or more, willing to give written consent to perform spirometry and the Mini-Mental State Examination (MMSE) [8], which is a screening test of cognition function. The exclusion criteria were severe dementia (a previously recorded or current MMSE <11/30), partly because we found in previous studies that such patients were unable to perform spirometry and partly on ethical advice that people with severe cognitive impairment would be unlikely to understand the study sufficiently to give informed consent, overt dyspraxia due, for example, to a stroke, impairment of vision or hearing to the extent that the patient could not understand the explanations and demonstrations of spirometry, contra-indications to spirometry such as recent eye surgery or pneumothorax, asthma or COPD not yet stable after an exacerbation, delirium, severe communication difficulties due to dysphasia. Patients who were dyspnoeic at rest were excluded as they were unlikely to be able to perform either SVC or FVC reliably. The subjects included patients with suspected asthma or COPD, though the majority had no indications of respiratory disease. Never-smokers, ex-smokers and current smokers were included.

The MMSE was measured after taking consent (no patients were found to have a post-consent MMSE <11/30 so all those giving consent were included). Spirometry was conducted on a single occasion by a fully trained researcher using a Microlabs® 3000 portable spirometer incorporating factory-set analytical software. Periodic calibration checks showed variations of less than 1% (<10 ml per litre) for volume and no detectable variation for time. Firstly, the researcher used one-to-one explanation, demonstration and practice to prepare the subject for an attempt at SVC. Each subject made at least two, and if necessary up to four, attempts to perform SVC, each starting from TLC and ending when flow has ceased for at least 1 s with continued expiratory effort. Secondly, after similar preparation the patient was asked to perform forced spirometry. Each made at least three attempts, and up to eight attempts were encouraged for those having difficulties achieving acceptable volume–time curves, if they were willing to keep trying to produce two acceptable and reproducible curves according to the European Respiratory Society/American Thoracic Society (ERS/ATS) criteria [9]. The time between attempts was 1–2 min and real-time visual displays of the spiromograms were used during the procedure to help the subjects and researcher to complete spirometry as accurately as possible. For FVC, in accordance with the ERS/ATS criteria, accurate spirometry was considered achieved if the subject produced at least three acceptable attempts (no artefacts, satisfactory start, at least 6 s duration and/or 1 s final zero-flow plateau), two of which were reproducible (<200 ml difference between the curves at FEV1 and FVC). For SVC, the attempt was deemed to be acceptable if the subject was observed to breathe in to TLC then breathe out completely until flow had ceased for at least 1 s. SVC measurements were considered to be reproducible if the two highest attempts varied by less than 200 ml.

Statistical methods

Categorical data were compared using Yates’ chi-squared test. Calculations were performed using Javastat online software [10].

Results

Of the 83 subjects, 38 were able to do both FVC and SVC, and 32 were unable to do either. The overall concordance was 84%. Twelve were able to do SVC but not FVC (eight due to uncontrollable coughing, two due to weakness and two had an MMSE <24/30 with poor co-ordination). None of the five patients with an MMSE <24/30 who tended to cough was able to maintain uninterrupted expiration in order to reach SVC.

There was a broad relationship between the MMSE and the proportion of subjects able to do spirometry (Table 1). However, this trend did not persist between MMSE scores of 24 and 30/30. Further, there was no apparent trend for improved ability to do SVC, but not FVC, in those with mild cognitive impairment compared with those with greater impairment. Only one subject was able to complete FVC but not SVC; the reason for this appeared to be an inability to sustain slow expiration without breathing in.
Table 1. Comparison of the numbers and percentages of patients able to perform slow vital capacity (SVC) and forced vital capacity (FVC) in MMSE score bands, n = 83

<table>
<thead>
<tr>
<th>MMSE score</th>
<th>Number (%) able to perform SVC</th>
<th>Number (%) able to perform FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15</td>
<td>1/10 (10)</td>
<td>1/10 (10)</td>
</tr>
<tr>
<td>15–19</td>
<td>5/16 (31)</td>
<td>4/16 (25)</td>
</tr>
<tr>
<td>20–23</td>
<td>10/23 (43)</td>
<td>9/23 (39)</td>
</tr>
<tr>
<td>24–30</td>
<td>28/34 (82)</td>
<td>24/34 (67)</td>
</tr>
</tbody>
</table>

Table 2. Comparison of subjects able to perform both forced vital capacity (FVC) and slow vital capacity (SVC) with subjects not able to do either. n = 70

<table>
<thead>
<tr>
<th>Able to do both FVC and SVC (n)</th>
<th>Unable to do FVC or SVC (n)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE &gt;23</td>
<td>24</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>MMSE &lt;24</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Predictive value of an MMSE <24/30 to identify elderly subjects who are likely to be unable to perform neither forced vital capacity (FVC) nor slow vital capacity (SVC). n = 70

<table>
<thead>
<tr>
<th>Predictive value</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>% (95% CI)</td>
<td>86 (77–95)</td>
<td>67 (56–73)</td>
<td>71 (63–77)</td>
<td>86 (73–94)</td>
</tr>
</tbody>
</table>

PPV = positive predictive value; NPV = negative predictive value; CI = confidence interval.

The overall spirometry results of the 38 subjects (28 female) able to perform both tests showed a mean (range) of 1.69L (0.81–4.01) and 1.68L (0.84–4.13) for FVC and SVC, respectively. The mean (range) percentage of predicted FVC was 83 (49–114). The coefficient of within-subject variation between FVC and SVC was 5.4%.

We carried out a further analysis of the 70 patients who had concordance between their FVC and SVC performance in order to explore the predictive value of the MMSE at the normative threshold of 24/30. As shown in Tables 2 and 3, an MMSE <24/30 (range 12–23, median 18, mean 19.8) predicted inability to perform neither FVC nor SVC with a high degree of sensitivity and moderate specificity in the 70 subjects whose performance in the two spirometric modes were either both satisfactory or both unsatisfactory. Inability to perform the tests was not related to the sex of the patient or to having evidence of airflow obstruction (14 subjects with an FEV1/FVC ratio <70%).

Discussion

We have shown that elderly patients with cognitive impairment are usually unable to perform FVC or SVC to an acceptable standard. Therefore, SVC cannot be seen as a useful alternative to FVC for such patients. This indicates that the SVC manoeuvre is of similar motor and temporal complexity to that needed for the FVC and requires a similar level of preserved cognitive function in the executive and praxis domains. On the other hand, the uncontrollable coughing that is triggered in some patients by attempting to record the FVC appears to be less likely to occur during SVC, so the latter can be of some clinical utility under those circumstances, providing the patient has little or no cognitive impairment. Patients with cognitive impairment who coughed during SVC appeared to be unable to continue to breathe out without breathing in. The apparent inability of cognitively impaired subjects to override mild coughing is probably a manifestation of executive dysfunction and renders SVC an unsuitable alternative in such circumstances. The study also confirms previous work [3, 5, 7] that has shown that the MMSE can be used to identify patients who are unlikely to perform spirometric tests reliably. The high sensitivity and moderate specificity of the MMSE as a predictive tool in this context are also in keeping with those earlier studies. Therefore, for practical purposes, clinicians can expect most elderly patients with an MMSE score of 24/30 or more to be able to perform FVC, and SVC is a useful alternative for those who cough during forced spirometry. A useful proportion of those with moderate impairment (MMSE 20–23) can also do adequate spirometry. As there is high concordance between ability to do FVC and SVC, it can be suggested that an initial attempt to perform SVC will not only provide a useful measure of lung volume in those who succeed but also identify those most likely to be able to proceed to a reliable FVC measurement.

The mean FVC and SVC were very similar, with a small coefficient of variation. To some extent this affirms the broad equivalence of the indices and supports their interchangeable value in clinical practice. In studies conducted on younger patients with COPD, it has been found that SVC is usually higher than FVC [11, 12], and it is argued that earlier closure of the small airways during forced expiration is the probable reason for the difference. Our sample had a small proportion of patients with airflow obstruction, which might be an explanation for the lack of a difference in FVC and SVC in this study. On the other hand, because of age-related changes in lung parenchymal compliance, a degree of airflow obstruction, defined as an FEV1/FVC ratio of less than 70%, is frequently observed even in never-smokers [13], in which case the SVC would be expected to be greater than the FVC in old age. The patients in the sample were frail, so another possible reason for the unexpectedly lower SVC might have been inability to sustain the last part of the end-expiratory effort to reach true residual volume, though we have no firm evidence of that fault occurring from our analysis of the SVC spiromgrams.

The study also highlights the role of cognitive function screening to identify patients who are unlikely to perform
unfamiliar sequenced motor tasks so that alternative approaches can be planned. Spirometry is just one example of that phenomenon. Others include self-administered dosing devices, such as inhalers [14, 15], nasal sprays [16], insulin pens [17] and complex drug regimens [18].

Key points

- Elderly patients with cognitive impairment are usually not able to perform forced spirometry.
- SVC is not a useful substitute for FVC in elderly patients with cognitive impairment.
- SVC is a useful substitute for FVC in elderly patients who tend to cough excessively during spirometry.
- An MMSE <24/30 predicts inability to perform SVC and FVC.

Conflicts of interest

None declared.

References


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