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Clinical and functional correlations of the difference between slow vital capacity and FVC

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ABSTRACT

Objective: To evaluate the relationship that the difference between slow vital capacity (SVC) and FVC (ΔSVC-FVC) has with demographic, clinical, and pulmonary function data. **Methods:** This was an analytical cross-sectional study in which participants completed a respiratory health questionnaire, as well as undergoing spirometry and plethysmography. The sample was divided into two groups: ΔSVC-FVC ≥ 200 mL and ΔSVC-FVC < 200 mL. The intergroup correlations were analyzed, and binomial logistic regression analysis was performed. **Results:** The sample comprised 187 individuals. In the sample as a whole, the mean ΔSVC-FVC was 0.17 ± 0.14 L, and 61 individuals (32.62%) had a ΔSVC-FVC ≥ 200 mL. The use of an SVC maneuver reduced the prevalence of nonspecific lung disease and of normal spirometry results by revealing obstructive lung disease (OLD). In the final logistic regression model (adjusted for weight and body mass index > 30 kg/m^2), OLD and findings of air trapping (high functional residual capacity and a low inspiratory capacity/TLC ratio) were predictors of a ΔSVC-FVC ≥ 200 mL. The chance of a bronchodilator response was found to be greater in the ΔSVC-FVC ≥ 200 mL group: for FEV1 (OR = 4.38; 95% CI: 1.45-13.26); and for FVC (OR = 3.83; 95% CI: 1.26-11.71). **Conclusions:** The use of an SVC maneuver appears to decrease the prevalence of nonspecific lung disease and of normal spirometry results. Individuals with a ΔSVC-FVC ≥ 200 mL, which is probably the result of OLD and air trapping, are apparently more likely to respond to bronchodilator administration.

Keywords: Vital capacity; Plethysmography; Airway obstruction.

INTRODUCTION

American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines recommend the use of slow VC (SVC) as the denominator to calculate the Tiffeneau index.[1] Despite this recommendation, SVC maneuvers are not routinely used in most pulmonary function laboratories in Brazil.

VC is determined by measuring the volume of air in the lungs after a maximal inhalation and after a maximal exhalation, i.e., TLC and RV, respectively, which include lung/chest wall compliance and elastic recoil, respiratory muscle strength, alveolar collapse, and airway closure.[2-4] In individuals with no chest wall or respiratory muscle abnormalities, TLC is determined by lung elastic recoil.[5] In young individuals, RV is primarily determined by static factors (chest wall elastic recoil and respiratory muscle pressure), whereas, in elderly individuals and in those presenting with airflow limitation, RV is determined by dynamic factors (expiratory flow limitation and airway closure).[3,6]

In normal individuals, VC reflects the properties of the lung parenchyma, whereas, in those with chronic obstructive lung disease, it reflects the properties of the airways.[5] In patients with airflow limitation, airway closure occurs at high lung volumes.[7] During an FVC maneuver, dynamic compression and airway collapse can lead to premature airway closure, thus reducing FVC. Reduced thoracic gas compression during an SVC maneuver explains the fact that, even in healthy individuals, there is a difference between SVC and FVC (ΔSVC-FVC), which is more pronounced in patients with obstructive lung disease (OLD).[5]

Few studies have examined the association of ΔSVC-FVC with demographic characteristics, lung function, respiratory symptoms, and lung disease.[4,8-10] To our knowledge, there have been no studies evaluating bronchodilator response in relation to ΔSVC-FVC.

The primary objective of the present study was to examine the association of ΔSVC-FVC with demographic variables, spirometric parameters, plethysmographic parameters, bronchodilator response, and lung function, as well as to identify factors independently associated with a ΔSVC-FVC ≥ 200 mL. A secondary objective was to examine the association of ΔSVC-FVC with the severity of OLD, respiratory symptoms, and clinical diagnosis, as well as to compare the spirometry results obtained with the use of FVC maneuvers alone and those obtained with the combined use of FVC and SVC maneuvers.

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METHODS

This was an analytical cross-sectional study. The study sample consisted of patients referred for pulmonary function testing between October 21, 2013 and July 28, 2015 at the *Instituto de Assistência Médica ao Servidor Público Estadual* (IAMSPE, Institute for the Medical Care of State Civil Servants), located in the city of São Paulo, Brazil. The study was approved by the Research Ethics Committee of the IAMSPE (Ruling no. 373,763, August 5, 2013).

Patients were randomly invited to participate in the study, and those who agreed gave written informed consent and completed a respiratory questionnaire,[11] which was administered by a nurse who is also a pulmonary function technician certified by the Brazilian Thoracic Association.

The inclusion criteria were being an outpatient and meeting the criteria established in studies reporting reference values for spirometry and plethysmography in Brazil.[12,13] The exclusion criteria were having performed spirometric or plethysmographic maneuvers that failed to meet the ATS/ERS acceptability and reproducibility criteria[14,15] and presenting with SVC < FVC.

Figure 1 shows a flow chart of the sample selection process. All participants performed SVC, FVC, and plethysmographic maneuvers (in this order) using a Collins system (Ferraris Respiratory, Louisville, CO, USA). All tests were performed by the aforementioned nurse, with participants in a sitting position and wearing a nose clip.

All tests were reviewed by the principal investigator and the coordinator of the pulmonary function laboratory. Emphasis was placed on the quality of inspiratory capacity (IC) maneuvers, which were performed in a relaxed manner after at least three stable breaths. IC was defined as the average of three reproducible measurements (a variability of ≤ 100 mL). The highest SVC value was selected from three measurements with a reproducibility of ≤ 100 mL. During FVC maneuvers, the difference between the two highest FVC and FEV_1 values was ≤ 150 mL and that between the two highest PEF values was ≤ 10%. The highest FVC and FEV_1 values were selected from those obtained during acceptable maneuvers, in accordance with the criterion of PEF reproducibility.[14,16]

With regard to plethysmography, functional residual capacity (FRC) was calculated from thoracic gas volume, at the end of tidal volume exhalation. TLC and RV were calculated by the following formulas: TLC = IC + FRC and RV = TLC − SVC.[15]

The results were interpreted in accordance with the ATS/ERS criteria.[1] Spirometry results were considered normal when values were above the lower limit of normal; OLD was defined as an FEV_1/(F)VC ratio below the lower limit of normal; nonspecific lung disease (NLD) was defined as a proportional reduction in (F)VC and FEV_1; and OLD with reduced (F)VC was defined as the presence of OLD associated with a reduction in (F)VC. First, we analyzed the spirometry results obtained with the use of FVC maneuvers alone; then, we analyzed those obtained with the combined use of FVC and SVC maneuvers.

Plethysmographic variables were then analyzed. Given that specific airway conductance (sGaw) is also a parameter of airflow limitation, sGaw values of < 0.12 [with or without reduced FEV_1/(F)VC ratio] were interpreted as indicative of OLD.[17,18] Air trapping was defined as an RV > 130%, and lung hyperinflation was defined as a TLC > 120%. All patients with reduced TLC were diagnosed with restrictive lung disease.[19] In such cases, the use of a fixed threshold is acceptable because of decreasing dispersion of the data around the predicted equation line.[20] The difference between TLC and FVC, a theoretical measure designated forced RV (FRV), was calculated and expressed as absolute values and as a percentage of the predicted values.

OLD was classified as mild (FEV_1 ≥ 60%), moderate (FEV_1 = 41-59%), or severe (FEV_1 ≤ 40%), in accordance with British Thoracic Society criteria.[21]

A subgroup of patients with OLD underwent spirometry 20 min after administration of a bronchodilator (400 µg of albuterol aerosol). A significant bronchodilator response was characterized by FVC and FEV_1 ≥ 200 mL and ≥ 7% of predicted; SVC ≥ 250 mL and ≥ 8% of predicted; and IC ≥ 300 mL.[22]

The study sample was divided into two groups: ΔSVC-FVC < 200, comprising patients in whom ΔSVC-FVC was < 200 mL (as assessed before bronchodilator administration); and ΔSVC-FVC ≥ 200, comprising patients in whom ΔSVC-FVC was ≥ 200 mL (as assessed before bronchodilator administration). The 200-mL threshold was used because it is higher than that used in order to assess reproducibility, as well as being higher than the mean ΔSVC-FVC values observed in healthy individuals.[8,9,23]

Statistical analysis

All statistical analyses were performed with the IBM SPSS Statistics software package, version 21.0 (IBM Corporation, Armonk, NY, USA). Data were expressed as means and standard deviations for quantitative variables and as absolute numbers and proportions for categorical variables. Normality of data distribution was assessed with the Kolmogorov-Smirnov test with Lilliefors correction.

Functional, demographic, and clinical parameters were compared between the groups with the use of the Student's t-test (for data with normal distribution) or the Mann-Whitney U test (for data with non-normal distribution). The kappa statistic was used in order to assess the agreement between the spirometry results obtained with FVC maneuvers alone and those obtained with FVC and SVC maneuvers in combination. Categorical variables were compared by the chi-square test or Fisher's exact test.

Correlations of ΔSVC-FVC with demographic, clinical, and functional variables were analyzed with Pearson's or Spearman's correlation coefficient, the former being

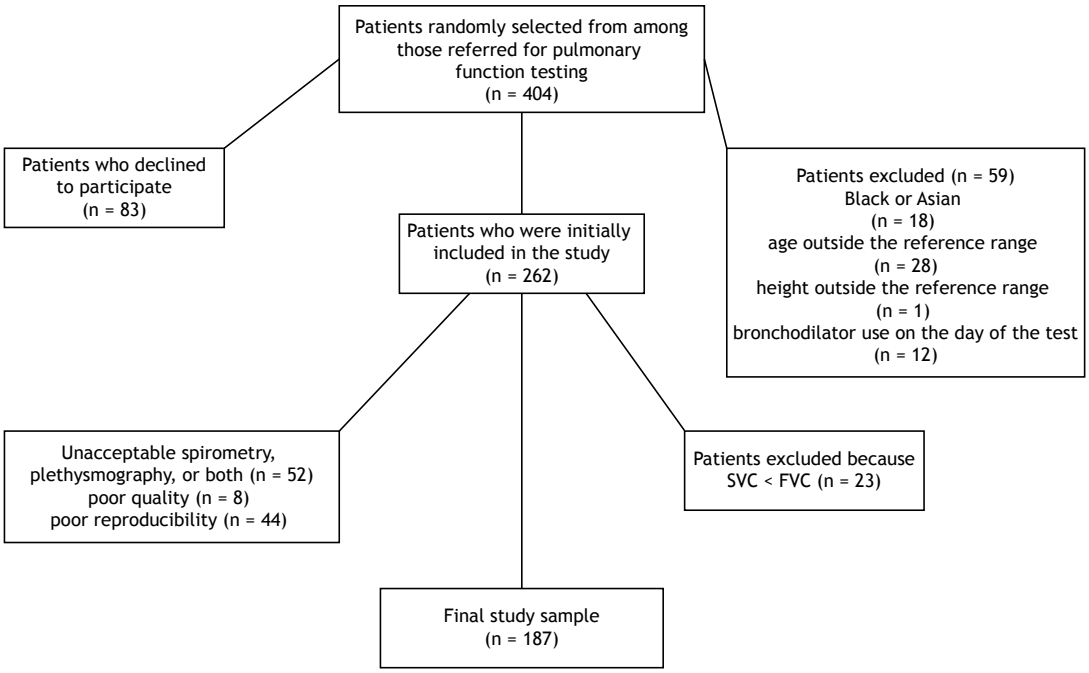

Figure 1. Flow chart of the sample selection process. SVC: slow vital capacity.

used for data with normal distribution and the latter being used for data with non-normal distribution.

Logistic regression analysis was performed to identify independent predictors of a ΔSVC-FVC ≥ 200 mL. First, a single logistic regression analysis was performed to determine the OR for each demographic variable. Then, a binomial logistic regression analysis was performed to evaluate spirometric and plethysmographic parameters, crude and adjusted ORs being calculated (for the variables that were significant in the single logistic regression model) to predict a ΔSVC-FVC ≥ 200 mL.

A multiple logistic regression analysis was performed to determine whether a ΔSVC-FVC ≥ 200 mL was a predictor of significant changes in spirometric parameters (FEV_1, FVC, SVC, and IC) after bronchodilator administration. It was also used in order to determine whether a ΔSVC-FVC ≥ 200 mL was predictive of normal TLC in cases in which spirometry results were indicative of NLD or of OLD with reduced FVC and a significant bronchodilator response. The level of significance was set at 5% for all analyses except the single logistic regression model, in which the level of significance was set at $p < 0.20$.

RESULTS

A total of 187 patients were selected (Figure 1). The general characteristics of the recruited population and a comparison between the two study groups are shown in Table 1. The mean age was 59.01 ± 12.80 years, and 126 patients (67.40%) were female. Mean height and weight were 159.90 ± 9.60 cm and 78.46 ± 18.48 kg, respectively. Mean ΔSVC-FVC was 0.17 L, a ΔSVC-FVC ≥ 200 mL being observed in 61 participants (32.62%). A ΔSVC-FVC ≥ 200 mL was observed in 28 (45.90%) of the 61 male participants and in 33 (26.20%) of the 126 female participants ($p = 0.007$). Height and weight were higher in the ΔSVC-FVC ≥ 200 group than in the ΔSVC-FVC group < 200 ($p = 0.002$ and $p = 0.017$, respectively). There were no significant differences between the two groups regarding body mass index (BMI) or clinical parameters (smoking and dyspnea). The Tiffeneau index was lower in the ΔSVC-FVC ≥ 200 group than in the ΔSVC-FVC < 200 group, whereas lung volumes were higher in the former than in the latter. A ΔSVC-FVC was significantly more common in patients with OLD, regardless of the severity of airflow obstruction.

Table 2 shows the agreement between the spirometry results obtained with FVC maneuvers alone and those obtained with FVC and SVC maneuvers in combination (kappa = 0.653). Of the 73 normal spirometry results obtained when FVC maneuvers were used in isolation, 21 were reclassified as OLD when FVC and SVC maneuvers were used in combination. Of the 32 cases that were diagnosed as NLD when FVC maneuvers were used in isolation, 17 were reclassified when FVC and SVC maneuvers were used in combination. Of the 28 spirometry results interpreted as OLD with reduced FVC when FVC maneuvers were used in isolation, 8 were reclassified as OLD when FVC and SVC maneuvers were used in combination. Of the 91 cases that were diagnosed as OLD when FVC and SVC maneuvers were used in combination, only 54 had been diagnosed as OLD when FVC maneuvers were used in isolation. When normal spirometry results were excluded from the analysis, the kappa statistic was lower (0.506).

Reports of improvement in wheezing after bronchodilator administration were more common in the ΔSVC-FVC

Table 1. General and functional characteristics of the sample as a whole and of the two study groups.[a]

Parameter	Total sample	Group		p
		ΔSVC-FVC < 200 mL	ΔSVC-FVC ≥ 200 mL	
	(n = 187)	(n = 126)	(n = 61)	
Male sex	61 (32.62)	33 (26.20)	28 (45.90)	0.007*
Female sex	126 (67.40)	93 (73.81)	33 (54.10)	
Age, years	59.01 ± 12.80	59.70 ± 13.11	57.61 ± 12.11	0.300*
Height, cm	159.90 ± 9.60	158.37 ± 9.23	163.00 ± 9.70	0.002*
Weight, kg	78.46 ± 18.48	76.25 ± 16.86	83.12 ± 20.90	0.017*
BMI, kg/m^2	30.45 ± 6.40	30.26 ± 6.20	30.85 ± 6.84	0.553*
Smoking history, pack-years	18.30 ± 27.20	16.17 ± 25.82	22.70 ± 29.60	0.110**
Dyspnea, mMRC scale score	1.0 [0.0-4.0]	1.0 [0.0-4.0]	1.0 [0.0-4.0]	0.570**
FVC, L	2.83 ± 0.91	2.73 ± 0.90	3.03 ± 0.90	0.035**
FVC, % predicted	84.72 ± 17.35	85.11 ± 17.67	83.90 ± 16.79	0.666*
FEV_1, L	2.02 ± 0.73	1.99 ± 0.71	2.08 ± 0.76	0.418*
FEV_1, % predicted	75.00 ± 18.94	76.56 ± 18.44	71.87 ± 19.58	0.116*
FEV_1/FVC	0.71 ± 0.12	0.73 ± 0.10	0.68 ± 0.12	0.017**
PEF, L/s	6.92 ± 5.00	6.97 ± 5.87	6.82 ± 2.33	0.587**
SVC, L	3.00 ± 0.94	2.83 ± 0.91	3.35 ± 0.92	< 0.001*
SVC, % predicted	89.20 ± 17.00	87.50 ± 17.06	92.70 ± 16.50	0.049*
IC, L	2.12 ± 0.63	2.05 ± 0.62	2.26 ± 0.63	0.034*
FEV_1/SVC	0.67 ± 0.11	0.70 ± 0.10	0.61 ± 0.11	< 0.001**
FRC, L	2.93 ± 0.94	2.79 ± 0.90	3.21 ± 0.97	0.002**
TLC, L	5.05 ± 1.27	4.84 ± 1.22	5.47 ± 1.27	0.001**
TLC, % predicted	94.44 ±16.70	93.73 ± 16.86	95.92 ± 16.34	0.402*
RV, L	2.05 ± 0.79	2.01 ± 0.76	2.12 ± 0.86	0.185**
RV, % predicted	127.34 ± 45.00	129.17 ± 43.61	123.54 ± 47.90	0.424*
RV/TLC	0.41 ± 0.12	0.42 ± 0.11	0.39 ± 0.12	0.086*
IC/TLC	0.42 ± 0.10	0.43 ± 0.09	0.42 ± 0.09	0.495*
sGaw, L/s/cmH_2O	0.12 ± 0.08	0.12 ± 0.08	0.11 ± 0.07	0.380**
FRV, L	2.22 ± 0.81	2.11 ± 0.76	2.44 ± 0.85	0.02**
FRV, % predicted	155.71± 41.00	152.00 ± 36.51	163.84 ± 48.26	0.059*
ΔSVC-FVC, L	0.17 ± 0.14	0.095 ± 0.052	0.321 ± 0.132	< 0.001*

ΔSVC-FVC: difference between slow VC and FVC; BMI: body mass index; mMRC: modified Medical Research Council; SVC: slow vital capacity; FRC: functional residual capacity; IC: inspiratory capacity; sGaw: specific airway conductance; and FRV: forced residual volume. [a]Values expressed as n (%), mean ± SD, or median [minimum-maximum]. *Student's t-test. **Mann-Whitney U test.

Table 2. Agreement between the spirometry results obtained with FVC maneuvers alone and those obtained with FVC and slow vital capacity maneuvers in combination.[a,b]

Functional diagnosis		FVC + SVC maneuvers				Total	kappa	p
		Normal	OLD	OLD with reduced VC	NLD			
FVC maneuvers	Normal	52	21	0	0	73	0.653	< 0.001
	OLD	0	54	0	0	54		
	OLD with reduced FVC	0	8	20	0	28		
	NLD	4	8	5	15	32		
	Total	56	91	25	15	187		

SVC: slow vital capacity; OLD: obstructive lung disease; and NLD: nonspecific lung disease. [a]Values expressed as n. [b]Values in bold indicate diagnoses that were the same regardless of the diagnostic method used.

≥ 200 group than in the ΔSVC-FVC < 200 group (p = 0.04), as assessed by the aforementioned respiratory questionnaire.[11] Of the 17 participants with a history of tuberculosis, only 1 was in the ΔSVC-FVC ≥ 200 group (p = 0.011). There were no significant differences between the two groups regarding clinical diagnosis (Table 3).

The use of Pearson's or Spearman's correlation coefficient (data not shown) showed that ΔSVC-FVC correlated positively with height, FVC (L), SVC (L), SVC (% predicted), IC (L), TLC (L), and FRV (% predicted), as well as correlating negatively with FEV_1/(F)VC, RV (% predicted), and RV/TLC.

Table 3. Clinical diagnoses based on a < 200 mL difference between slow VC and FVC in comparison with those based on a ≥ 200 mL difference between slow VC and FVC.

Diagnosis	ΔSVC-FVC < 200 mL (n = 126)		ΔSVC-FVC ≥ 200 mL (n = 61)		p*
	n	%	n	%	
Unknown	33	26.20	16	26.23	0.566
Asthma	31	24.40	14	23.00	
COPD	15	11.80	10	16.40	
ILD	17	13.40	7	11.50	
Rhinitis	6	4.70	1	1.60	
Bronchiolitis	7	5.50	3	4.90	
Asthma + other	5	3.90	1	1.60	
COPD + other	0	0.00	2	3.30	
Other	12	9.40	7	11.50	

ΔSVC-FVC: difference between slow VC and FVC; and ILD: interstitial lung disease. *Fisher's exact test.

Table 4. Evaluation of demographic parameters (initial model) and functional parameters (final model) predicting a ≥ 200 mL difference between slow VC and FVC by logistic regression.

Initial model		
Demographic parameter	OR (95% CI)	p
Age, years	1.348 (0.501-3.629)	0.554
Female sex	0.774 (0.318-1.883)	0.572
Height, cm	1.016 (0.947-1.090)	0.655
Weight, kg	1.036 (0.983-1.091)	0.183
BMI, kg/m^2	1.038 (0.887-1.215)	0.644
BMI > 30 kg/m^2	5.075 (1.583-16.270)	0.006
Final model		
Functional parameter	Crude OR (95% CI)	Adjusted OR (95% CI)
FVC, L	1.425 (1.015-2.002)	1.020 (0.687-1.513)
FVC, % predicted	0.996 (0.979-1.014)	0.992 (0.974-1.011)
FEV_1, L	1.190 (0.782-1.812)	0.711 (0.426-1.188)
FEV_1, % predicted	0.987 (0.971-1.003)	0.980 (0.962-0.998)
FEV_1/FVC	0.967 (0.940-0.994)	0.952 (0.922-0.983)
SVC, L	1.831 (1.296-2.586)	1.399 (0.951-2.058)
SVC, % predicted	1.019 (1.000-1.038)	1.018 (0.997-1.038)
IC, L	1.695 (1.035-2.776)	1.014 (0.557-1.845)
FEV_1/SVC	0.931 (0.902-0.960)	0.908 (0.875-0.943)
TLC, L	1.492 (1.156-1.924)	1.282 (0.895-1.685)
TLC, % predicted	1.008 (0.989-1.027)	1.016 (0.995-1.037)
RV, L	1.188 (0.811-1.742)	1.201 (0.806-1.790)
RV, % predicted	0.997 (0.990-1.004)	1.002 (0.994-1.009)
RV/TLC	0.099 (0.007-1.400)	0.561 (0.030-10.561)
FRC, L	1.614 (1.155-2.255)	1.532 (1.063-2.808)
sGaw, cmH_2O/L/s	0.143 (0.003-8.005)	0.032 (0.000-3.000)
IC/TLC	0.988 (0.955-1.022)	0.956 (0.917-0.998)
FRV, L	1.692 (1.142-2.505)	1.697 (1.119-2.572)
FRV, % predicted	1.007 (1.000-1.015)	1.000 (0.992-1.009)
OLD_{FVC}	1.677 (0.906-3.107)	1.879 (0.948-3.723)
OLD_{SVC}	5.597 (2.543-12.322)	9.444 (3.708-24.049)
OLD_{PLET}	2.250 (1.151-4.397)	3.225 (1.497-6.948)

BMI: body mass index; SVC: slow vital capacity; IC: inspiratory capacity; FRC: functional residual capacity; sGaw: specific airway conductance; FRV: forced residual volume; OLD: obstructive lung disease; PLET: plethysmography.

As can be seen in Table 4, binomial logistic regression showed that weight and BMI > 30 kg/m^2 were predictors of a ΔSVC-FVC ≥ 200 mL (p < 0.20). Crude and adjusted ORs were calculated for weight and BMI > 30 kg/m^2 by means of a logistic regression analysis to evaluate spirometric and plethysmographic parameters. Reduced FEV_1 (% predicted), FEV_1/FVC, FEV_1/SVC, and IC/TLC, as well as increased FRC (L) and FRV (L),

Table 5. Multiple logistic regression analysis of bronchodilator response for a ≥ 200 mL difference between slow VC and FVC.[a]

Parameter	OR	95% CI	Pseudo r^2	p
FEV_1	4.38	1.45-13.26	0.112	0.009
FVC	3.83	1.26-11.71	0.090	0.018
SVC	0.63	0.38-4.91	0.040	0.630
IC	2.14	0.53-8.64	0.018	0.284
Any parameter responding positively	4.74	1.65-13.56	0.136	0.040

SVC: slow vital capacity; and IC: inspiratory capacity. [a]In comparison with a < 200 mL difference.

were independent predictors of a ΔSVC-FVC ≥ 200 mL. Increased SVC, IC, and TLC were associated with a ΔSVC-FVC ≥ 200 mL, albeit only in the crude model. OLD (characterized by reduced FEV_1/SVC, reduced sGaw, or a combination of the two) was independently associated with a ΔSVC-FVC ≥ 200 mL.

As can be seen in Table 5, our multiple logistic regression model showed that individuals with a ΔSVC-FVC ≥ 200 mL were more likely to show a significant change in FEV_1 (OR = 4.38; 95% CI: 1.45-13.26) and FVC (OR = 3.83; 95% CI: 1.26-11.71) than were those with a ΔSVC-FVC < 200 mL. However, in cases in which spirometry results were indicative of NLD or of OLD with reduced FVC and a significant bronchodilator response, a ΔSVC-FVC ≥ 200 mL failed to predict normal TLC (OR = 1.705; 95% CI: 0.333-8.721).

DISCUSSION

The use of SVC and FEV_1/SVC in the present study reduced the prevalence of NLD and of normal spirometry results by revealing airflow obstruction that can go unnoticed when only FVC and FEV_1/FVC are analyzed. Reductions in percent predicted FEV_1 and in FEV_1/(F)VC, as well as the presence of OLD, together with findings suggestive of air trapping (increased FRC and reduced IC/TLC),[24] were factors independently associated with a ΔSVC-FVC ≥ 200 mL. A significant bronchodilator response was more likely to occur in cases in which the ΔSVC-FVC was ≥ 200 mL.

In the present study, the spirometry results obtained with the combined use of FVC and SVC maneuvers changed the functional diagnosis that had been established with the use of FVC maneuvers alone. Of the 73 patients whose spirometry results were normal when FVC maneuvers were used in isolation, 21 were diagnosed with OLD when FVC and SVC maneuvers were used in combination. It has been reported that the prevalence of COPD in patients with mild disease is higher when assessed by FEV_1/SVC than when assessed by FEV_1/FVC.[25] Therefore, the FEV_1/SVC ratio plays an important role in revealing airflow limitation in smokers with respiratory symptoms and impaired quality of life presenting with normal FEV_1/FVC, thus contributing to an early diagnosis of COPD. However, in the present study, a ΔSVC-FVC ≥ 200 mL was found to be independent of the severity of OLD, a finding that is inconsistent with those of other studies.[4,5]

The use of SVC maneuvers in combination with FVC maneuvers changed the results of spirometry in 8 of 28 cases of OLD with reduced FVC (those 8 being reclassified as cases of OLD) and in 12 of 32 cases of NLD (those 12 being reclassified as normal cases [n = 4] or as cases of OLD [n = 8]). VC accounts for approximately 75% of TLC.[19] A finding of normal SVC is important because it can prevent the need for plethysmography in selected cases (given the difficulty of access to the test and the associated health care costs), especially in those in which a diagnosis of restrictive lung disease is less likely. However, a ΔSVC-FVC ≥ 200 mL failed to predict normal TLC in our sample.

In our initial logistic regression model, weight and a BMI > 30 kg/m^2 were predictors of a ΔSVC-FVC ≥ 200 mL. The association between weight and ΔSVC-FVC might be due to premature airway closure, given that there was no association with sGaw. Data from a large study suggest that ΔSVC-FVC is proportional to the increase in BMI, suggesting that obesity reduces FVC more than it does SVC; in contrast, in individuals with normal BMI and without OLD, SVC can be lower than FVC.[10]

Wang et al.[26] divided their study sample into two groups, namely those with SVC = FVC and those with SVC > FVC, and found that 65% of the sample had SVC > FVC, a finding that was more common in older individuals. In the present study, age was not associated with ΔSVC-FVC; however, the mean age of our sample was considerably high (i.e., 59 years), and it was impossible to establish a comparison with younger individuals.

Lung volumes (TLC, FRC, SVC, and IC) were predictors of a ΔSVC-FVC ≥ 200 mL, although only in the crude logistic regression analysis. Markers of airflow limitation (reduced FEV_1/FVC and FEV_1/SVC) and findings of air trapping (such as increased FRC and reduced IC/TLC)[24] were independent predictors of a ΔSVC-FVC ≥ 200 mL.

The magnitude of ΔSVC-FVC correlated negatively with RV and positively with FRV. This was confirmed by our logistic regression model, in which FRV (although not RV) was independently associated with the probability of a ΔSVC-FVC ≥ 200 mL. This might be due to the fact that measured VC is higher during a SVC maneuver because of reduced thoracic gas compression, leading to reduced RV if we assume that TLC remains unchanged. Conversely, during a FVC maneuver, increased thoracic gas compression can result in airflow limitation, leading to reduced FVC and, consequently, increased FRV.

Multiple logistic regression analysis showed that improvements in FEV_1 and FVC after bronchodilator administration were more common in the ΔSVC-FVC ≥ 200 group than in the ΔSVC-FVC < 200 group. This raises the question of whether significant or nonsignificant bronchodilator response can differentiate between true obstruction and a variant of normality, respectively, in individuals with an isolated finding of ΔSVC-FVC ≥ 200 mL. In the present study, no association was found between ΔSVC-FVC and OLD or restrictive lung disease/NLD.

The present study has some limitations. Strict inclusion criteria resulted in a limited sample size. In addition, there was no control group (comprising healthy individuals); most of the study sample consisted of diseased individuals.

Future studies should determine whether ΔSVC-FVC can predict exercise-induced hyperinflation and its association with the small airways (as assessed by imaging and biochemistry).

In conclusion, the use of an SVC maneuver appears to reduce the prevalence of NLD. Although it is possible that ΔSVC-FVC is due to airflow limitation and air trapping, it might be due to dynamic compression of the airways during exercise. Individuals with a ΔSVC-FVC ≥ 200 mL are more likely to have a significant bronchodilator response.

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