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Original articles

Accuracy of single-breath counting test to determine slow vital capacity in hospitalized patients

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Conflict of interests: Nonexistent

ABSTRACT

Purpose: to identify the accuracy of the single-breath counting test to determine slow vital capacity in hospitalized patients and to evaluate the repeatability of the same examiner.

Methods: a diagnostic study and the choice of techniques were randomly assigned. The area under the curve (receiver operating characteristic) was calculated from the slow vital capacity (20ml/kg) to evaluate the best psychometric characteristics of single-breath counting Test for this cutoff point. Repeatability observed by the same examiner was assessed using the Intraclass Correlation Coefficient.

Results: 516 patients hospitalized for various diseases were analyzed. In the curve analysis (receiver operating characteristic/slow vital capacity=20ml/Kg), the value of 21 in single-breath counting test with a sensitivity of 94.44% and specificity of 76.62% (area under the curve =0.93, p<0.005) was found. The intraclass correlation coefficient value for the single-breath counting test was 0.976 with p>0.005.

Conclusion: the single-breath counting test was a valid and repetitive technique, and may be an important screening option for assessment of lung function in the absence of specific equipment. This technique opens perspectives to replace slow vital capacity measurement in hospitals, which lack spirometric equipment, or in patients who may have a contagious disease, which has a risk of contamination and spread of disease from one patient to another.

Keywords: Spirometry; Lung Diseases; Vital Capacity; Phonation

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INTRODUCTION

Measurements of lung volumes are used in clinical practice in order to screen for functional abnormalities and to estimate the degree of loss of pulmonary function[1-9]. One of these volumes is the slow vital capacity (SVC), defined as the largest amount of air a person can exhale, slowly, after a maximal inspiration[2,3,6]. A complete pulmonary functional evaluation includes many other measurements[7], but we have been investigating the SVC and the single-breath counting test (NC abbreviation for numerical counting) as quantitative screening tools for obstructive or restrictive processes in circumstances where more refined and costly equipment to measure functional deficits are not available[10-12]. We have also studied the utility of the maximal phonation time (MPT). We would like to better define the practical utility of NC & MPT in our Brazilian hospital. This study seeks to define how well NC may correlate with spirometric through the validity of the NC from a slow vital capacity value previously set and repeatability by the same examiner.

METHODS

This research was conducted on the hospital wards and the intensive care unit in a reference public hospital in the city of Petrolina, Brazil, from May 2012 to January 2014 after approval by the Ethics Committee of Universidade de Pernambuco under the Number 478.571(CAAE: 20222613.5.0000.5207). It is part of a larger study that analyzes the behavior of the slow vital capacity and the maximum phonation time of a research group of the cardiopulmonary laboratory of the University. All volunteers were informed about the research objectives as well as their rights as participants and signed an informed consent.

This was a diagnostic study and the order of the tests execution (spirometry technique and numerical count) were performed randomly (simple draw). All procedures were performed by previously trained researchers.

Study participants were hospitalized individuals of both sexes aware, aged 18-80 years and presenting with lung diseases, neurological, oncological, cardiac, hepatic, infections and postoperative of general surgery. Exclusion criteria were hemodynamically unstable individuals, respiratory rate above 30 breaths per minute, signs of hypoxemia (SpO_2 <90%), asthma attacks and in patients who could not conduct the investigation because of pain or failure to understand the performing technique. Patients whose medical record or interview suggested inflammatory disease, infection or injury in the upper respiratory tract were also excluded. The assessment would be interrupted if the patient had any discomfort during the procedure or if any parameter described in exclusion criteria was found after the tests started (no patient was discontinued).

Individual variables measured were height, total body mass (TBM), age, gender, cause of hospitalization, slow vital capacity and numerical counting. Evaluator following the standardization of the International Society for the Advancement of Kinanthropometry (ISAK)[13] conducted the measurement of TBM and height. For both measurements, we used digital scale (G-TECH, Pernambuco, Brazil) and tape (Joamarca, São Paulo, Brazil). The age, sex and cause of hospitalization variables were obtained from medical records or interview. The SVC was measured by the MicroQuarck spirometer (Cosmed - Italy).

Spirometry is a validated method used throughout the world as a reference standard for assessing slow vital capacity for many years[2]. In the evaluation the subject was instructed to make a maximal inspiration to reach total lung capacity and then to blow all the air through on the device slowly until reaching the residual volume. We chose the best measurement from three attempts, with a rest period of two minutes between each maneuver[2,11,12]. To perform the calculation of SVC by relative form was used the following equation [female = 45 + 0.93 x (height - 152.4); Man = 50 + 0.91 x (height - 152.4)][11,12]. The value categorized from 20 ml/kg was chosen as the cutoff point for evaluating the receiver operator characteristic curve (ROC), because a SVC below this value was described as need for intervention[5].

We then estimated the SVC by the technique of counting numbers (NC). The individual was asked to inspire as much air as possible and during exhalation begin to counting numbers in ascending order, beginning with the numeral one to the greatest number that he/she could reach in a single exhalation[11,12]. The value chosen for analysis also was the best in three attempts, following a one-minute rest between measurements. The rest time between one technique and another one was five minutes and during test (SVC and NC) the patients were instructed to stay in bed in the sitting position.

Repeatability of the NC and SVC were performed by the same researcher and the choice of techniques were conducted randomly in the first and second evaluation, with a minimum interval of six hours and a maximum of eight hours after the first evaluation. Repeatability was performed in the first stage of the study in the first 70 patients. This sample size is described as sufficient for repeatability studies with good statistical power.

Statistical Analysis

The data were processed and analyzed using the Graph Pad Instat program (Graph Pad Inc., San Diego, USA, Release 3:06, 2003). Initially were subjected to normality criteria (Kolmogorov-Smirnov test). Mean and standard deviation (SD) were used to present continuous variables, while categorical data were presented by absolute and relative frequencies. Bilateral p values were calculated, and the significance level was 5%.

To assess the cutoff point of numerical counting technique, a ROC curve was plotted and the area under the curve was calculated. Was established as the best cut point for the NC one with the highest sum of sensitivity and specificity[14]. From the value found in NC we calculated the positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio.

For the evaluation of test-retest was used the Intraclass Correlation Coefficient (ICC), the intra-examiner method and the standard error of measurement was calculated from the formula: SEM: SD √ (1 - ICC), where SD is the standard deviation of mean at baseline; and ICC value was derived from test-retest reliability[15].

RESULTS

Evaluations were made on 516 hospitalized individuals with different causes of hospital admission and 54% (270) were male and 46% (246) female. The mean age (± SD) was 37 ± 31.11 years. The general characteristics of the sample are shown in Table 1.

Table 1. General characteristics of the sample

Variáveis	**Hospitalizados (n=516)**
Age (years)	37 ± 31.11
TBM (kg)	58 ± 10.8
Ideal weight (kg)	61.4 ± 3.3
Height (m)	1.66 ± 9.2
SVC (ml)	3235 ±1746
SVC (ml/kg)	51.4 ± 30.3
NC (counting)	27 ± 18.3
Gender	
Females	246 (46%)
Males	270 (54%)
Clinical diagnosis	
Lung diseases	76 (14.7%)
Heart diseases	98 (18.9%)
Oncologial diseases	33 (6.3%)
Neurological diseases	42 (8.1%)
Liver diseases	37 (9.8%)
Urinary diseases	34 (7.1%)
PO trauma surgery	86 (16.6%)
PO cardiac surgery	39 (7.5%)
PO abdominal surgery	71 (10.4%)

Data are expressed as mean ± standard deviation or absolute numbers (%). TBM = Total body mass; SVC = slow vital capacity; NC = number counting technique; PO = postoperative. M=meters Ml = millimeters.

Figure 1 shows the value of the numerical count technique 21 found through the analysis of the ROC curve for the categorized SVC value of 20 ml / kg with a sensitivity of 94.44%, a specificity of 76.62% and area under the ROC curve of 0.93 (95% CI, 0.90 to 0.96; p <0.005). The predictive values (positive and negative), accuracy, and likelihood ratio values (positive and negative) are in Table 2.

The intra-rater reliability is demonstrated by intra-class correlation coefficient (ICC) and standard error of measurement (SEM). The results showed excellent intra-rater reliability as counting technique as SVC (Table 3).

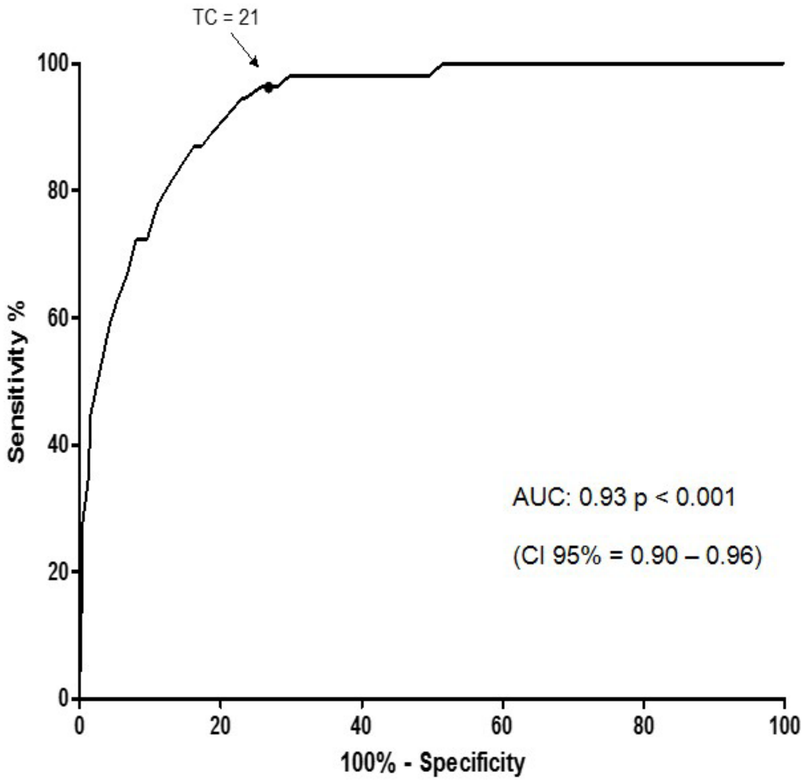

Figure 1. Area under the curve from Numerical Counting technique for predicting the Slow Vital Capacity in hospitalized patients. TC = Counting Technique; AUC = Area Under the Curve; CI = confidence interval.

Table 2. Sensitivity, specificity, predictive values and likelihood of numerical counting technique for a vital capacity of 20 millimeters / kilogram

Cutoff point	SEN	ESP	ACC	PPV	NPV	PLR	NLR
NC = 21	94.44	76.62	78.49	32.08	99.16	4.04	0.07

NC = Numerical Count technique; SEN: sensitivity; ESP: specificity; ACC: accuracy; PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

Table 3. Intra-rater reliability through the intraclass correlation coefficient and standard error of measurement in the first 70 patients evaluated

	Evaluator Moment 1	Evaluator Moment 2	ICC (CI 95%)	SEM
NC	28.37 ± 16.87	26.86 ± 16.65	0.976 (0.961-0.985)	0.80
SVC ml	2619.56 ± 1025.95	2424.49 ± 1029.23	0.962 (0.938-0.976)	14.99
SVC ml/Kg	43.28 ± 13.84	40.11 ± 14.76	0.950 (0.919-0.969)	031

NC = Numerical Count technique; SVC = slow vital capacity; ICC = interclass correlation coefficient; SEM = Standard Measurement Error; CI = confidence interval; ML = millimeters; Kg = kilogram

DISCUSSION

This study showed that the numerical count technique in hospitalized individuals presented a good validity with the Slow Vital Capacity (SVC) and excellent intra-examiner repeatability. It can be useful for evaluation of lung function with Numerical Count Technical values (NC) lower 21, reflecting an SVC below 20 ml/kg. This research suggests that in the absence of specific equipment, the NC may be a good screening option for a more specific test, because the patients classified with a NC under 21, 94.44% were with a SVC below 20 ml/kg, which would indicate a possible need therapeutics[5]. However, it was not a specific test because the positive predictive value indicated that among patients with altered NC, the probability of SVC altered was only 32%. In addition, some individuals classified with a possible limitation in the test, could have no problem (specificity = 76.62%), being important the diagnostic confirmation.

Individuals hospitalized can have decreased SVC regardless of the reason that led to hospitalization, and identify this functional limitation in various diseases, can help treat them adequate[3-5,16-18]. Vital capacity lower than 20 ml/kg is described in the literature[5] as an important value to trace possible interventions in patients regardless of the related disease, confirming the purpose of this research that does not separate individuals by disease, indicating that simply viewing a decrease in these values for starting treatment.

As the lung function is directly related to voice production, individuals with lung disease may have changed MPT and reduction in the amount of air available to support phonation[11,12,19]. Some researchers just associated the MPT with the inspiratory peak flow[20] and VO_2[21], however, associations between MPT and the SVC is relatively recent in the literature. Two Brazilian studies found a positive correlation between SVC and NC in healthy individuals[11] and hospitalized[12], found a much higher correlation in hospitalized. This finding had already been reported by the study Toyoda et al.[22] who found no correlation in healthy subjects, however the authors did not evaluate the MPT by NC. Healthy individuals may not have presented good correlation in previous studies because despite the anthropometric characteristics of each individual vary, the value show little variation, showing proportionality, unlike hospitalized patients with very different values for both the SVC and MPT.

Latronico et al.[16], reported that a rough estimate of the SVC could be done by counting technique, and that individuals with neuromuscular diseases unable to count to 20 have a SVC around 15-18 ml/kg, which is indicated, performing noninvasive ventilation as an intervention technique in these patients. Despite this publication agree with the proposal of this research because count below 21 indicates the need for intervention, the said research is just one of opinion reports, and was not found in the literature studies attempting to validate the NC as an alternative to measure the SVC.

Speyer et al.[23], evaluated the repeatability of MPT in a group of outpatients with functional or organic dysphonia, compared with a control group of healthy individuals. The patients presented maximum phonation times shorter compared to the control group (average 6.6 shorter). The authors concluded that the maximum phonation time proved to be a highly reliable measure in assessing voice and a single evaluator is sufficient to provide reliable measurements. This research also showed excellent intra-rater reliability for both the SVC and for the MPT with an intra-class reliability index ICC = 0.976 for NC and ICC = 0.962 for SVC, the main difference being the use of hospitalized individuals, and NC as a means of assessing the MPT for the measurement of SVC. Another finding of this research was that the standard error of measurement related to NC, objective evaluation of the ICC, did not represent even a drive in this way an individual account to any number would have an error in the amount of 0.8 to more or less evaluated by the same examiner.

This research suggests the use of NC as an option for the evaluation of pulmonary function of patients hospitalized in the absence of specific equipment, especially for screening those who need intervention. However, this technique should not be used to the detriment of methods already established, and doubt or suspicion of divergent outcomes, spirometry or ventilometry should be the method of choice. The ability to perform this test in any environment as clinics, the bedside and in health care is quite inspiring.

However, have included patients with different characteristics in the same analysis, it may have been a possible limitation of this study, however we sought to evaluate pulmonary functional limitation of the patient. This same proposal has been described in the literature to evaluate the SVC and indication of possible interventions in hospitalized individuals regardless of the disease, as studies of the recommendations of the Brazilian Department of Intensive Care Medicine Association of Physiotherapy[5] and the European task force Respiratory Society and European Society of

Intensive Care Medicine[4]. Thus, it is suggested to future studies that separately assess individuals by disease. Another issue to be considered is the possibility of time variations as a function of glottic efficiency, not necessarily in the dependence only of the SVC, or patients with glottic chink and therefore with voice impact, which may present a reduction in MPT. In order to limit these questions, patients who in the medical records or during the interview reported inflammation, infection or upper respiratory tract injury were excluded. It is important to highlight the importance of the present study, since the results described here may support research that seeks to compare individuals with the same characteristics, healthy and who can control patients with voice problems.

CONCLUSION

The importance of this study is highlighted, because NC is a noninvasive, fast, cheap method, that does not require the use of specific devices and only uses the voice as a resource. The present study found NC as validity and repeatability, and it may be an important screening option for assessment of lung function in the absence of specific equipment.

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