Medical Journal of the
Islamic Republic of Iran

Volume 19
Number 1
Spring 1384
May 2005

CALCULATION OF RESIDUAL VOLUME BY SPIROMETRIC DATA

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ABSTRACT

Background: The current practice to measure RV is either by BPG or helium dilution methods which may not be available in all clinics due to their cost.

Methods: This paper outlines a method for both direct and indirect calculation of RV via PFT with acceptable sensitivity (81%, 60%), specificity (71%, 94%) and validity (76%, 78%) for obstructive and restrictive lung disease respectively at a much lower cost.

MJIRI, Vol. 19, No. 1, 49-51, 2005.

Keywords: RV: Residual Volume, BPG: Body Plethysmography, PFT: Pulmonary Function Test, FRC: Functional Residual Capacity, ERV: Expiratory Reserve Volume.

INTRODUCTION

The measurement of FRC and TLC is dependent on the measurement of RV which is carried out by either BPG or helium dilution method. In the former a special chamber containing a spirometer is used where the subject is placed inside and is totally isolated from outside.

By measuring certain parameters FRC is calculated from the following formula (Boyle's law):

$FRC.P_1 = (FRC+dv).P_2$

Having found FRC from the above and measuring ERV from the spirometric method, RV is then calculated by subtracting the two values.

In the helium dilution method, however, FRC is calculated from the following formula:

$V.C_b = FRC.C_a$

where C_b and C_a are the concentration of helium before and after inhalation and V is the initial volume of helium. As in the previous method RV is calculated from subtraction of FRC and ERV. Despite being the standard method, the above produces varied results under the same conditions.

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MATERIAL AND METHODS

Theory

Principally RV is dependent on two parameters, namely vital capacity and degree of obstruction. Therefore it can be stated that:

$$RV\ measured = RV\ predicted \times K \qquad (F1)$$

Where K is an index defined as % vital capacity / % obstruction, i.e. the RV measured is a fraction of RV predicted. It is possible to calculate percentages of vital capacity and obstruction by using the ratio of FVC measured / FVC predicted over mean obstruction of large and small airways, i.e. ½ (%FEV1 measured /FVC measured + % FEF 25-75 measured / FEF 25-75 predicted) respectively. Therefore formula (1) can be expressed as:

$$RV\ measured = RV\ predicted \times \frac{2 \times \frac{FVC\ measured}{FVC\ predicted}}{\%\frac{FEV1measured}{FVC\ measured} + \%\frac{FEF25\text{-}75measured}{FEF25\text{-}75predicted}} \qquad (F2)$$

or

$$\frac{RV\ measured}{RV\ predicted} = \frac{2 \times \frac{FVC\ measured}{FVC\ predicted}}{\%\frac{FEV1measured}{FVC\ measured} + \%\frac{FEF25\text{-}75measured}{FEF25\text{-}75predicted}} \qquad (F3)$$

Now RV predicted in males and females is calculated as follows:

Males RV predicted= 0.022Age+1.98H-0.013w-1.54±0.4 (F4)
Females RVpredicted= 0.007Age+2.66H-3.42±0.4 (F5)

It is therefore possible to easily calculate RV measured by having %FVCm/FVCp, %FEV1m/FVCm, FEF25-75m/FEF25-75p which are obtained by PFT.

RESULTS

A sample size of 110 cases who were referred to Sasan Hospital for BPG were considered over a period of 4 years. These patients were also tested for PFT at the same time.

Table I shows the results of RV obtained from BPG (gold standard) and that calculated from formula (2) suggested in this paper; then the two values were compared using paired t-test which was not significant (pv>0.5) with a correlation coefficient of (r= 0.78).

Table I. Results of calculated and measured RV by the two methods.

No.	BPG RV	F2 RV
1	1.5	1.3
2	2.5	1.9
3	2.8	2.5
.	.	.
.	.	.
.	.	.
	Mean X	Mean Y

Using formula (3) RVm / RVp was also compared with that of RV measured / RV predicted obtained from BPG in obstructive and restrictive lung disease. Tables II and III are the results of comparing data in obstructive and restrictive lung diseases respectively.

Table II. Comparing RV ratio in obstruction by the two methods.

		%RVm/RVp calculated	
		⩾120%	<120%
(BPG) %RVm/RVp	⩾120%	44	10
	<120%	16	40

Obstruction

sensitivity= 81% specificity= 71% validity= 76% PPV=73% NPV=80% K agreement test (Cronbach)= +0.53

Table III. Comparing RV Ratio in Restriction by the two methods.

		%RVm/RVp calculated	
		<80%	⩾ 80%
(BPG) %RVm/RVp	<80%	6	4
	⩾ 80%	6	94

Restriction

sensitivity=60% specificity=94% validity=78% PPV=50% NPV=96% K agreement test (Cronbach)=+0.47

DISCUSSION

Finding a spirometic method for calculation of RV (vs. measurement) not only improves the evaluation and analysis of PFT but also decreases the cost. Calculation of RV is dependent on two parameters, lung volume (vital capacity) and degree of large and small airway obstruction which is shown as %FEV1 and %FEV 25-75 respectively. Thus RVm can be calculated as a fraction of RVp using formulas 2 and 3.

As indicated in formulas 4 and 5 and 95% CI a range for RVp is obtained. Comparing the two values without using this range shows a correlation coefficient (r = 0.78) for the two methods, but using the range for RVp, RVm is within the range in 91%.

Finally clinical use of this method shows that calculation of RV by the method suggested in this paper using both formula 1 and 2 is an acceptable method for determining the presence of obstructive lung disease with a sensitivity of 81% and specificity of 71% and validity of 76% and restrictive lung disease with a sensitivity of 60%, specificity of 94% and validity of 78%.

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