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LUNG FUNCTION TESTS IN CLINICAL DIAGNOSIS OF PULMONARY EMPHYSEMA

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Summary. *Pulmonary function studies were performed in 25 patients with pulmonary emphysema, diagnosed by clinical, roentgenographic and functional examinations. Lung function tests included spirometry, flow-volume curve, body plethysmography and single breathholding carbon monoxide transfer test. The spirometric ratio of forced expiratory to forced inspiratory volumes for the first 0.5 second ($FEV_{0.5}/FIV_{0.5}$) was also calculated. Mean spirometric results, as the percentage of predicted, were: vital capacity (VC)=57.6%, forced expiratory volume in one second (FEV_1)=30.0% and 100·FEV_1/VC=37.2. The ratio $FEV_{0.5}/FIV_{0.5}$ was 0.39±0.14. The flow-volume curve showed low expiratory flows in all patients and collapsing shape in 20 out of 25 patients (80%). Body plethysmography revealed mean airway resistance (Raw)=0.54 kPa·l^{-1}·s, thoracic gas volume (TGV)=218%, total lung capacity (TLC)=140.5%, and 100·RV/TLC=63.9. Transfer factor (TL_{CO}) was 49±19.6%, and transfer coefficient (K_{CO}) 47±21.1% of predicted. It is concluded that lung ventilation tests in pulmonary emphysema patients are characterised by severe obstructive ventilatory impairment, increased TLC, decreased pulmonary diffusing capacity and severe lung hyperinflation. Statistical analysis in this study shows that among ventilatory tests, the ratio $FEV_{0.5}/FIV_{0.5}<0.62$ (i.e. result below the statistical level of mean+1.64 SD, found in emphysema patients) is the best indicator of lung emphysema obtainable by routine spirometry, showing highly significant correlation with TL_{CO} ($r = 0.772$; $p<0.001$) and K_{CO} ($r = 0.679$; $p<0.001$). It is suggested that this ratio should be included in the computer program of routine spirometers.*

Key words: *Pulmonary emphysema, diagnosis, lung function*

Introduction

Pulmonary emphysema is observed most commonly as a component of chronic obstructive pulmonary disease (COPD), which is defined as a disease state characterised by the presence of chronic airflow obstruction due to chronic bronchitis or emphysema (1**)**. The airflow limitation is generally progressive, may be accompanied by airway hyperreactivity and may be partially reversible in chronic bronchitis, while mostly irreversible in emphysema.

Emphysema is defined anatomically by abnormal permanent enlargement of the airspaces distal to the terminal bronchioles, accompanied by destruction of their walls and without obvious fibrosis (1,2). While chronic bronchitis is defined in clinical terms, pulmonary emphysema is defined in terms of anatomic pathology. On the basis of this definition, the precise diagnosis of emphysema can be established by the pathohistologic examination of lung tissue specimen, which is not convenient in clinical practice. Therefore, clinical approach to the diagnosis of pulmonary emphysema must be based on complex examinations, including history, physical examination, chest radiography and lung function tests. The most significant functional tests for pulmonary emphysema are usually complicated, as lung transfer factor (diffusing capacity) and lung compliance measurements. These tests are not available in many functional laboratories. For that reason, this study was done with the aim to make an attempt to help establishing the diagnosis of pulmonary emphysema using less complicated and easy available tests of lung function.

Patients and Methods

The study was done on 25 patients with pulmonary emphysema. Their anthropometric characteristics are presented in table 1. The diagnosis of pulmonary emphysema was confirmed by clinical, roentgenographic and functional examinations. Lung function tests included spirometry, flow-volume curve, body plethysmography and single-breath carbon monoxide transfer test. The reversibility of obstructive airflow limitation was estimated by bronchodilator tests (3), taking levels for indicating positive or negative bronhodilating response both a proportional increase for 12% (4) or

15% (5), as well as a minimum absolute increase, usually 200 ml (6) over baseline.

Spirometry included measurements of vital capacity (VC), forced expiratory volume for one second (FEV_1) and the ratio $100 \cdot FEV_1/VC$. Additional determination of the ratio of forced expiratory to forced inspiratory volumes for the first 0.5 second ($FEV_{0.5}/FIV_{0.5}$) was performed during spirometry (7).

The flow-volume curve was analysed by observing its shape and by measuring the flows at following points: peak expiratory flow (PEF), forced expiratory flow at the 50% level of FVC (FEF_{50}), and forced expiratory flow at the 25% level of FVC (FEF_{25}).

Body plethysmography was used for the measurements of airway resistance (Raw) and thoracic gas volume (TGV) with the calculations of residual volume (RV), total lung capacity (TLC) and the ratio $100 \cdot RV/TLC$.

Single-breath carbon monoxide transfer test (8) was used for the measurement of lung transfer factor for carbon monoxide (TL_{CO}) and the calculation of transfer coefficient (K_{CO}).

The measured values, obtained by lung function tests, were also expressed as percentages of the reference values (9). The correlation between transfer factor measurements and the results of lung ventilation tests was estimated by the appropriate statistical method.

Results

Anthropometric characteristics of examined patients with pulmonary emphysema (table 1) showed that they were mostly middle aged males (only 2 out of 25 were females), with average body height and body mass within usual ranges for our population.

Table 1. Anthropometric characteristics of examined patients

	Number of patients	Age of patients (years)	Body height (cm)	Body mass (kg)
Males	23			
Females	2			
Total	25	57.4 ± 9.7	171 ± 7.1	67.0± 9.7

Table 2. Spirometric results in 25 emphysema patients

	Mean ± SD	% of predicted
VC (l)	2.38 ± 0.68	57.6 ± 15.7
FEV_1 (l)	0.96 ± 0.45	30.0 ± 14.6
$100 \cdot FEV_1/VC$	37.2 ± 10.7	
$FEV_{0.5}/FIV_{0.5}$	0.39 ± 0.14	

Table 3. Forced expiratory flows in emphysema patients

	Mean ± SD	% of predicted
PEF (l/s)	3.65 ± 1.13	44.4 ± 13.7
FEF_{50} (l/s)	0.58 ± 0.37	13.3 ± 8.4
FEF_{25} (l/s)	0.32 ± 0.11	19.1 ± 7.1

Spirometric results are presented in table 2. These results show severe ventilatory impairments predominantly of obstructive type. Additional calculation revealed markedly low ratio $FEV_{0.5}/FIV_{0.5}$ which averaged 0.39±0.14. The flow-volume curve showed collapsing shape in 20 out of 25 patients (80% of cases) with very low all values of forced expiratory flows (table 3). The results of body plethysmography (table 4) revealed significantly increased TLC, RV and the ratio $100 \cdot RV/TLC$, with moderately increased mean airway resistance (Raw) which was 0.54 $kPa \cdot l^{-1} \cdot s$. The mean values of transfer factor for carbon monoxide (TL_{CO}) and transfer coefficient (K_{CO}) were markedly reduced to 49.2% and 46.9% respectively (table 5). The correlation coefficients between the results of transfer test and all observed lung ventilatory parameters were calculated.

Table 4. Body plethysmography in 25 emphysema patients

	Mean ± SD	% of predicted
VC (l)	7.28 ± 1.36	218.0 ± 36.4
RV (l)	6.25 ± 1.45	304.1 ± 86.7
TLC (l)	9.07 ± 1.35	140.5 ± 18.2
$100 \cdot RV/TLC$	63.9 ± 8.49	
Raw ($kPa \cdot l^{-1} \cdot s$)	0.54 ± 0.23	

Table 5. Lung diffusing capacity in emphysema patients

	Mean ± SD	% of predicted
TL_{CO} ($mmol \cdot min^{-1} \cdot kPa^{-1}$)	4.29 ± 2.00	49.2 ± 19.6
K_{CO} ($mmol \cdot min^{-1} \cdot kPa^{-1} \cdot l^{-1}$)	0.84 ± 0.40	46.9 ± 21.1

Discussion

The single breath carbon monoxide transfer test is commonly used in differential diagnosis of chronic obstructive pulmonary disease. A reduction in transfer factor (TL_{CO}) and transfer coefficient (K_{CO}) is the best functional indicator of the presence and severity of pulmonary emphysema (2). In this context K_{CO} is more specific than TL_{CO} (6). Reduction of K_{CO} is related to the extent of emphysema found at autopsy (10) and by computed tomography (CT) scanning (11). Although non-specific, it is of great clinical value in distinguishing patients with pulmonary emphysema from the patients with chronic obstructive bronchitis and bronchial asthma, in whom the values of transfer tests are generally not reduced.

However, the transfer test requires a rather complicated procedure and equipment, usually available only in a limited number of highly specialised medical institutions. Therefore, an attempt was made in this study to estimate the value and usefulness of more common simple tests for lung ventilation, especially spirometry and flow-volume curve, in clinical diagnosis of pulmonary emphysema. The idea was to assess which test of lung ventilation showed the best correlation with the single-breath carbon monoxide transfer test as the

most relevant functional test for clinical diagnosis of emphysema.

The obtained results showed that lung ventilation tests in pulmonary emphysema patients were characterised by severe obstructive ventilatory impairment with significantly increased TLC and severe lung hyperinflation. Flow-volume curve showed very low expiratory flow rates and typical collapsing shape in 80% of emphysema patients. Among ventilatory tests, the spirometric ratio $FEV_{0.5}/FIV_{0.5}$ showed the best correlation with TL_{CO} ($r=0.772$; $p<0.001$) and K_{CO} ($r=0.679$; $p<0.001$). Statistical analysis of our results revealed that the value of the ratio $FEV_{0.5}/FIV_{0.5}<0.62$ (*i.e.* result below the statistical level of mean +1.64 SD, found in emphysema patients) was the best indicator of lung emphysema obtainable by routine spirometry. On the basis of these results a suggestion was made that determination of the ratio $FEV_{0.5}/FIV_{0.5}$ should be included in the computer program of routine spirometers.

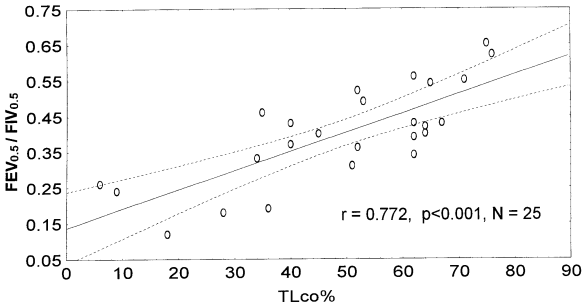

Fig. 1. Correlation between $FEV_{0.5}$ / $FIV_{0.5}$ and TLCO in emphysema patients

Conclusions

Pulmonary emphysema is associated with severe airflow obstruction which can be detected by spirometry, flow-volume curve and body plethysmography. As obstructive ventilatory impairment is described in all patients with COPD, it is not specific for pulmonary emphysema.

Among lung ventilation tests, ratio $FEV_{0.5}/FIV_{0.5}$ shows the best and highly significant correlation with TL_{CO} and K_{CO} and its value <0.62 is confirmed as the best indicator of lung emphysema which can be obtained by routine spirometry. Therefore, determination of the ratio $FEV_{0.5}/FIV_{0.5}$ should be included in the computer program of routine spirometers.

The collapsing shape of flow-volume curve is present in 80% of emphysema patients and comes into view as another useful sign of pulmonary emphysema.

Increased total lung capacity over 130% of predicted remains the third ventilatory change, indicative for pulmonary emphysema.

References

1. American Thoracic Society Statement. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 1995; 152: S77-S120.
2. Siafakas NM, Vermeire P, Pride NB, Paoletti P, Gibson J, Howard P, Yernault J-C, Decramer M, Higenbottam T, Postma DS, Rees J. Optimal assessment and management of chronic obstructive pulmonary disease (COPD). Eur Respir J, 1995; 8: 1398-1420.
3. Elliasson O, Degraff AC. The use of criteria for reversibility and obstruction to define patient groups for bronchodilator trials. Am Rev Respir Dis 1985; 132: 858-864.
4. American Thoracic Society. Lung function testing: Selection of reference values and interpretative strategies. Am Rev Resp Dis 1991; 144: 1202-1228.
5. British Thoracic Society. Guidelines for the management of COPD. Thorax 1997; 52 (Suppl. 5): 57.
6. Gibson GJ, MacNee W. Chronic obstructive pulmonary disease: investigations and assessment of severity. In: Management of chronic obstructive pulmonary disease. European Respiratory Monograph 1998; No. 7: 25-40.
7. Kikuchi Y, Takishima T. Essentials of clinical spirometry. RT International 1993; 2: 43-47.
8. Cotes JE, Chinn DJ, Quanjer PH, Roca J, Yernault J-C. Standardisation of the measurement of transfer factor (diffusing capacity). Eur Respir J 1993; 6 (Suppl. 16): 41-53.
9. Quanjer PH, Tammeling GJ, Cotes JE, Pedersen OF, Peslin R, Yernault J-C. Lung volumes and forced ventilatory flows. Eur Respir J 1993; 6 (Suppl. 16): 5-40.
10. Burrows B, Fletcher CM, Heard BE, Jones NL, Wotliff JS. The emphysematous and bronchial types of chronic airway obstruction. Lancet 1966; i: 830-835.
11. Gould GA, Redpath AT, Ryan M, Warren PM, Best JJ, Flenley DC, MacNee W. Lung CT density correlates with measurements of airflow limitation and the diffusing capacity. Eur Respir J 1991; 4: 141-146.

TESTOVI PLUĆNE FUNKCIJE U KLINIČKOJ DIJAGNOSTICI EMFIZEMA PLUĆA

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Kratak sadržaj: *Ispitivanje plućne funkcije izvršeno je kod 25 bolesnika s plućnim emfizemom, dijagnostikovanim kliničkim, rendgenografskim i funkcijskim pregledima. Testovi plućne funkcije obuhvatili su spirometriju, krivulju protok-volumen, telesnu pletizmografiju i transfer-test za ugljen-monoksid metodom jednog udaha. Takođe je izračunavan spirometrijski odnos između forsiranog ekspirijumskog i inspirijumskog volumena za prvih 0,5 s ($FEV_{0.5}/FIV_{0.5}$). Srednje vrednosti spirometrijskih rezultata, u obliku procenata od referentnih vrednosti, bile su: vitalni kapacitet (VC=57.6%, forsirani ekspirijumski volumen u prvoj sekundi (FEV_1=30.0%, i odnos $100 \cdot FEV_1/VC = 37.2$. Odnos $FEV_{0.5}/FIV_{0.5}$ je bio 0.39±0.14. Krivulja protok-volumen pokazala je niske vrednosti ekspirijumskih protoka kod svih bolesnika i kolapsni oblik kod 20 od 25 bolesnika (80%). Telesna pletizmografija je otkrila prosečan otpor u disajnim putevima (Raw)=0.54 $kPa \cdot l^{-1} \cdot s$, toraksni gasni volumen (TGV)=218%, totalni plućni kapacitet (TLC)=140.5% i odnos $100 \cdot RV/TLC = 63.9$. Transfer-faktor (TL_{CO}) je bio 49±19.6%, a koeficijent transfera (K_{CO}) 47±21.1% od referentnih vrednosti. Zaključeno je da se testovi plućne funkcije kod bolesnika s emfizemom pluća odlikuju teškim opstrukcijskim poremećajem ventilacije, povećanim TLC, smanjennim difuzijskim kapacitetom pluća i teškom hiperinflacijom pluća. Statistička analiza u ovoj studiji pokazala je da, među testovima ventilacije pluća, odnos $FEV_{0.5}/FIV_{0.5} < 0.62$ (tj. rezultat ispod statističkog nivoa koji predstavlja srednja vrednost+1.64 standardne devijacije, dobijenog kod bolesnika s emfizemom) jeste najbolji pokazatelj plućnog emfizema koji se može dobiti rutinskom spirometrijom, a pokazuje vrlo visoku korelaciju sa TL_{CO} ($r = 0.772$; $p<0.001$) i K_{CO} ($r = 0.679$; $p<0.001$). Predloženo je da se ovaj odnos uključi u računarski program rutinskih spirometara.*

Ključne reči: Emfizem pluća, dijagnoza, plućna funkcija

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