Pulmonary function test abnormalities in the elderly with systolic heart failure

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Abstract

Background: An association between chronic heart failure (CHF) and pulmonary function abnormalities is clinicaly important. Spirometry is frequently used to evaluate lung function.

Aim: To evaluate some spirometric parameters in the elderly with newly diagnosed or known systolic CHF.

Methods: The study group consisted of 110 patients (74 men – 67.3%) who underwent echocardiography as well as spirometry with reversibility test. Heart failure was diagnosed using the guidelines of the European Society of Cardiology and Framingham criteria. The average age of the patients was 68.5±8.9 years. Smokers constituted 54.5% of the group. Concomittant deseaes included arterial hypertension (86.4%), diabetes type 2 (20.9%), and myocardial infarction (49.1%). At the beginning of the study, 54.5% of the patients had already been taking beta-blockers, 84.5% angiotensin-converting enzyme inhibitors, 83.6% diuretics, 30% calcium channel blockers, and 92.7% aspirin. Echocardiography revealed left ventricular ejection fraction (LVEF) below 45% in 74 (67.3%) patients.

Results: All analysed spirometric parameters were abnormal in CHF patients. A multivariable analysis revealed that age, smoking and LVEF were the only independent parameters which significantly effected FEV_1 – one of the most important spirometric parameters.

Conclusions: In patients with systolic CHF, independently of the treatment, mixed ventilation disorders were observed, which had a positive reversibility test. Apart from impaired LVEF, older age as well as smoking significantly influenced the deterioration of ventilatory parameters.

Key words: spirometry, heart failure, elderly

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Introduction

Chronic heart failure (CHF) affects 0.4-2.0% of the European population and results from such common diseases as hypertension, valve disorders and, most often, ischaemic heart disease [1].

Heart failure is characterised by decreased blood flow through the vital organs, including pulmonary circulation. It is particulary associated with dysfunction of the left ventricle (LV), biventricular failure and right ventricular dysfunction coexisting with mitral stenosis [2-6].

The relationship between CHF and respiratory dysfunction was extensively studied, and the assessment of respiratory function with spirometry, in addition to the clinical, echocardiographic, radiological and biochemical evaluation, gained a lot of attention [1]. In patients with pulmonary oedema, restrictive ventilatory abnormalities were described, and they tended to be present even before overt clinical manifestations or radiological features of CHF. Mild or moderate obstructive abnormalities most commonly coexist with CHF, particularly when respiratory disorders are also present [4].

Muscle weakness and peribronchial oedema are considered to be responsible for the development and exacerbation of respiratory tract disorders in patients

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with CHF [7, 8]. As a result, according to the few published studies, patients with CHF, together with higher respiratory flow resistance, measured by oscilometric methods, as compared to healthy individuals [9, 10].

The aim of the study was to evaluate selected spirometric parameters of respiratory capacity in elderly patients with newly diagnosed or established and treated CHF.

Methods

Patients

The study included 110 patients with diagnosed CHF based on the ESC 2001 criteria and treated in our department between December 2003 and January 2005. The clinical criteria for inclusion in the study were dyspnoea (exertional or nocturnal), peripheral oedema, orthopnoea, signs of ischaemia in ECG, the presence of rales over the lung fields, jugular filling, hepatomegaly and positive hepatojugular reflux. Radiological criteria included enlargement of the heart transverse dimension as well as signs of congestion in the pulmonary circulation.

The exclusion criteria were as follows: history of bronchial asthma, chronic obstructive pulmonary disease, tuberculosis or malignancy.

The patients were treated with angiotensin-converting enzyme inhibitors (ACE-I), aspirin, diuretics, calcium-channel blockers and beta-blockers. All patients are given a questionnaire (including questions about the clinical symptoms, the previous history of the disease, current medications, addictions, risk factors, and previous cardiovascular complications). Also spirometry, both basic and post-dilatation (spirometric assessment 20 minutes after inhalation of 200 ug of salbutamol administered through the air chamber), and echocardiography were performed.

Spirometry

The spirometry test was performed using a Lungtest 1000S device (MES, Cracow), according to the recommendations of the European Respiratory Society published in 1993 [11]. At least 3 repeatable measurements of flow-volume curves were obtained with particular attention to the measurement of the following parameters: forced vital capacity (FVC), forced expiratory volume during the first second of expiration (FEV_1), forced expiratory volume during the first second of expiration after inhalation of short-fast-acting beta-2-mimetic (FEV_1R), peak expiratory flow (PEF), and the maximum mean expiratory flows between 75% and 25% of FVC (MEF_{75}, MEF_{50}, MEF_{25}).

Echocardiographic examination

Echocardiographic examination was performed with a GE 3 Ultrasound device equipped with a 2.5-3.5 MHz probe, in 2-D and M-mode, in parasternal and apical views to assess systolic function of the LV. Left ventricular ejection fraction (LVEF) was measured planimetrically from a four-chamber apical view.

Statistical analysis

The spirometric parameters were compared in patients with LVEF <45% and ≥45%. The Statistica 6.0 software, normality tests, Student's t-test, U Mann-Whitney test, χ^2 test and Pearson correlation analysis were utilised for initial statistical analysis. Multivariable regression analysis was used to select factors independently correlated with the analysed data.

Results

A group of 110 patients – 36 (32.7%) women and 74 (67.3%) men was studied. The mean age of the examined population was 68.5±8.9 years. Sixty (54.5%) patients were current smokers. The comorbidities included: hypertension (AH) in 86.4% of the patients, type 2 diabetes mellitus (DM) in 20.9% of the patients and history of myocardial infarction (MI) in 49.1% of the patients. At baseline 54.5% of the individuals were treated with beta-blockers, 84.5% received ACE-I, 83% diuretics, 30% calcium channels blockers (CCB) and 92.7% aspirin (ASA).

On echocardiography, LVEF <45% was found in 74 (67.3%) patients. 25.5% of the patients were in NYHA class I, 17.3% in class II, 54.5% in class III and 2.7% in class IV. The characteristics of the patients in relation to the systolic function of the LV are presented in Table I.

It was found that patients with decreased LVEF more often had a history of MI and were treated with ACE-I, diuretics, and calcium channels blockers; there were also significantly more current smokers among them.

All the analysed spirometric parameters were significantly reduced in the patients with LVEF <45% (Table II). The patients with decreased contractility of the LV were found to have mild to moderate mixed ventilatory abnormalities, with mean reversibility of obstruction amounting to 15.03%. In this group, the volume criteria were also fulfilled, with a mean increase of FEV_1 in the dilatation test of 410 ml. In the patients with normal contractility of the LV, the obstruction reversibility test was negative, with a mean increase of FEV_1 of 5.71% (p=0.000017).

To identify factors having a potential effect on the ventilatory parameters in the examined group, a multivariable statistical analysis was performed. The following parameters having a potential impact on FEV_1

Table I. Comparison of patients with normal (LVEF ≥45%) or impaired (LVEF <45%) LV systolic function

Parameter	LVEF <45%	LVEF ≥45%	p
Number of patients	74	36	
Males	48 (64.9%)	26 (72.1%)	NS
Age [years]	69.2±9.09	68.3±10.27	NS
Smoking	45 (60.8%)	15 (41.7%)	0.05
Hypertension	70 (94.6%)	31 (86.1%)	NS
Diabetes mellitus	39 (52.7%)	12 (33.3%)	NS
Myocardial infarction	57 (77%)	9 (25%)	0.0001
Beta-blockers	44 (59.4%)	16 (44.4%)	NS
Angiotensin-converting enzyme inhibitors	68 (91.9%)	25 (69.4%)	0.001
Diuretics	73 (98.6%)	19 (52.8%)	0.0001
Calcium channel blockers	27 (36.5%)	6 (16.7%)	0.01
Aspirin	71 (95.9%)	31 (86.1%)	NS
LVEF	35.2±5.09	54.2±6.93	0.0001

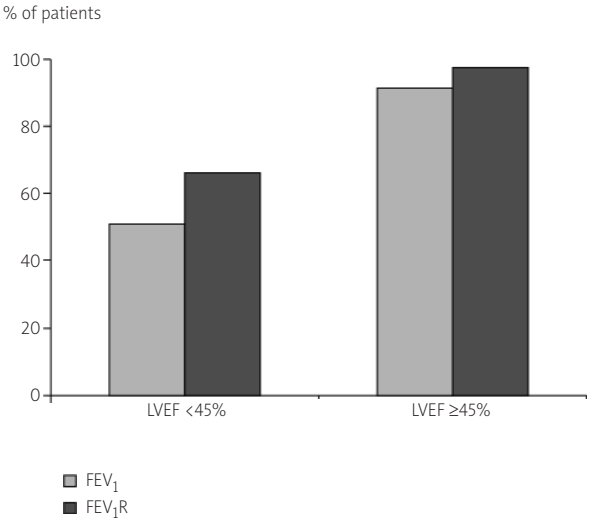

Figure 1. The relationship between LVEF, FEV_1 and FEV_1R in examined population (p <0.0001)
Abbreviations: LVEF – left ventricular ejecion fraction, FEV_1 – forced expiratory volume during the first second of expiration, FEV_1R – forced expiratory volume during the first second of expiration after inhalation of 200 µg of salbutamol

were included in the analysis: age, gender, LVEF, cigarette smoking and used medications.

A significant correlation between FEV_1 and LVEF was found (r=0.69, p <0.0001). When the variables showing a significant correlation in the monofactorial analysis and the patients' gender were included in the multivariable regression model, factors independently associated with FEV_1 values included age (beta=0.27±0.10; p=0.009), cigarette smoking (beta=–0.28±0.09; p=0.002) and LVEF (beta=0.78±0.10; p <0.001). The remaining correlations did not reach statistical significance (Figure 1).

Table II. Spirometric parameters in relation to the presence of systolic CHF

Parameter	LVEF <45%	LVEF ≥45
Number of patients	74	36
FEV_1 [l]	1.41±0.6	2.58±0.87*
FEV_1 [%N]	51.31±19.83	91.00±20.82*
FEV_1R [%N]	66.34±23.47	96.71±20.12*
$FEV_1R – FEV_1$ [l]	0.41±0.17	0.16±0.05*
FVC [l]	2.55±0.69	3.53±0.94*
FVC [%N]	71.55±0.55	97.10±0.94*
FEV_1%FVC	73.31±19.51	97.23±11.58*
PEF [%N]	37.05±23.16	71.8±29.13*

** p <0.0001*
Abbreviations: FVC – forced vital capacity, FEV_1 – forced expiratory volume during the first second of expiration, FEV_1R – forced expiratory volume during the first second of expiration after inhalation of 200 µg of salbutamol, $FEV_1R – FEV_1$ – difference in the rise of forced expiratory volume during the first second of expiration after the inhalation test, VC – vital capacity, FEV1%FVC – FEV_1/FVC rate × 100%, PEF – peak expiratory flow
%N – the percentage of a due value; due values were assessed on the basis of guidelines provided by: Standardization of lung function tests, 1993 update. Official statement European Respiratory Society. Eur Respir J 1993; 6 (Suppl. 16): 41–53

Discussion

The ventilatory parameters assessed by spirometric test in the patients with LV systolic dysfunction were significantly lower compared with the patients with normal systolic LV function.

This suggests that the patients with CHF suffer for mixed ventilatory abnormalities; however, it should be remembered that in our study there were more smokers among the patients with decreased LVEF,

which could have affected the final result. Nevertheless, a possible coexistence of CHF and chronic obstructive pulmonary disease in the study group should be considered. The published data suggest that mild to moderate obstruction usually accompanies CHF, particularly if respiratory disorders are also present [4, 12-14].

In the patients with pulmonary oedema, restrictive ventilatory abnormalities were reported, which might be present even before the clinical or radiological symptoms occur. Even though the respiratory system changes were more significant in the patients with the right ventricular failure, a relationship between the degree of these changes and the severity of CHF was noted, which might be explained by muscle weakness and peribronchial oedema observed in this group of patients [4, 7, 8]. Moreover, in comparison to healthy individuals, the patients with CHF have higher airflow resistance, measured with oscilometric method [9]. In the examined group of patients, more abnormal results obtained in the spirometric test were due to not only impaired systolic function of the LV, but also to cigarette smoking and the older age of the examined population. In the smoking patients, the annual decrease of FEV_1 assessed with the use of serial spirometric tests is known to become more intense with age. It is particularly evident in white males [15].

In our study, the patients with impaired systolic function of the LV showed mild to moderate mixed ventilatory abnormalities, with obstruction reversibility of 15.03% (compared with the initial value); the volume criteria were also fulfilled, with a mean increase of FEV_1 in dilatation test of 410 ml. Such a good response to inhaled bronchodilatory agents might suggest that there are many individuals with undiagnosed bronchial asthma in the group of patients with decreased LVEF. It should be considered that, also in healthy subjects, ventilatory parameters possibly improve after inhalation of beta-mimetic agents, but never to such an extent. Furthermore, together with the decrease of VC observed in this group of patients, the presence of restrictive ventilatory disorders might also be suggested. In order to unequivocally assess the type of pathology, total lung capacity (TLC) should be assessed, using, for example, plethysmographic examination.

The effect of beta-blockers used in the treatment of CHF on the spirometric parameters did not reach statistical significance in multivariable analysis. The lack of such a correlation could be explained by a much stronger influence of the impaired LV systolic function on ventilatory parameters, as well as by a more cardioselective action of currently used medications. Such a correlation was previously demonstrated by many investigators, and confirmed by Grosgurin et al. and Salpeter et al. [16, 17]. Even though the use of beta blockers did not significantly influence the ventilatory parameters, it might be assumed that the analysis of the effects of individual agents on spirometric parameters could reveal significant impact of some of them.

Even though the spirometric test is relatively easy to perform and its results are reproducible [18-20], some difficulties might occur in the group of older patients, limiting good cooperation between patients and medical staff. Such difficulties very often prevent proper conduction of the spirometric examination. In elderly patients, it might be very difficult or even impossible to obtain an adequate and repeatable result due to deafness, vision disorders, motor function impairment and frequent neurological complications of chronic disorders. A slight weakness of respiratory muscles, particularly of the diaphragm, was also observed in the patients with CHF, which was associated mostly with the predominance of free fibres in the diaphragm's structure [11], as well as with profound metabolic abnormalities in the skeletal muscles, leading to their dysfunction. Along with the difficulties resulting from the possible imperfect cooperation with the examined patients, another limiting factor is the lack of residual volume measurement that can be performed only by cabinet plethysmography, which enables precise identification of mixed (obstructive-restrictive) respiratory abnormalities.

Conclusion

In patients with systolic CHF, irrespectively of the administered treatment, mixed ventilatory abnormalities were observed and showed a good response to inhaled bronchodilatory agents (mean increase of 15.03% compared to baseline values). Besides, the impaired systolic function of the LV, cigarette smoking and older age of the subjects significantly worsened the ventilatory parameters in the studied group of patients.

References

1. Remme WJ, Swedberg K; Task Force for the Diagnosis and Treatment of Chronic Heart Failure, European Society of Cardiology. Guidelines for the diagnosis and treatment of chronic heart failure. *Eur Heart J* 2001; 22: 1527-60.
2. Murray JF. The Normal Lung: The Basis for Diagnosis and Treatment of Pulmonary Diseases, 2nd ed. *W.B. Saunders,* Philadelphia 1985.
3. Murray JF, Nadel JA (eds.). Textbook of respiratory medicine. *W.B. Saunders*, Philadelphia 1996.
4. Said SI (ed.). The Pulmonary Circulation and Acute Lung Injury. *Futura. Mount Kisko,* NY 1985.

5. Weibel ER. The Pathway for Oxygen: Structure and Function the Mammalian Respiratory System. *Harvard University Press. Cambridge*, MA 1984.
6. Griffith KA, Sherrill DL, Siegel EM, et al. Predictors of loss of lung function in the elderly: the Cardiovascular Health Study. *Am J Respir Crit Care Med* 2001; 163: 61-8.
7. Winter UJ, Gitt AK, Blaum M, et al. Cardiopulmonary capacity in patients with coronary heart disease. *Z Kardiol* 1994; 83 Suppl 3: 73-82.
8. Ricart S, Casan P, Bellido-Casado J, et al. Lung function in cardiac dysfunction. *Arch Bronconeumol* 2004; 40: 62-6.
9. Witte KK, Morice A, Clark AL, et al. Airway resistance in chronic heart failure measured by impulse oscillometry. *J Card Fail* 2002; 8: 225-31.
10. Hughes PD, Polkey MI, Harrus ML, et al. Diaphragm strength in chronic heart failure. *Am J Respir Crit Care Med* 1999; 160: 529-34.
11. Quanjer PH, Tammeling GJ, Cotes JE, et al. Lung volumes and forced ventilatory flows. Report Working Party Standardization of Lung Function Tests, European Community for Steel and Coal. Official Statement of the European Respiratory Society. *Eur Respir J Suppl* 1993; 5-40.
12. Waxman AB. Pulmonary function test abnormalities in pulmonary vascular disease and chronic heart failure. *Clin Chest Med* 2001; 22: 751-8.
13. Dimopoulou I, Daganou M, Tsintzas OK, et al. Effects of severity of long-standing congestive heart failure on pulmonary function. *Respir Med* 1998; 92: 1321-5.
14. Evans SA, Kinnear WJ, Watson L, et al. Breathlessness and exercise capacity in heart failure: the role of bronchial obstruction and responsiveness. *Int J Cardiol* 1996; 57: 233-40.
15. Global Strategy for the Diagnosis, Management and Prevention of COPD, Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2006. Available from: http://www.goldcopd.org.
16. Grosgurin O, Bria A, Gaspoz JM. Beta-blockers and obstructive pulmonary diseases: such an odd couple? *Rev Med Suisse* 2006; 2: 285-8.
17. Salpeter S, Ormiston T, Salpeter E. Cardioselective beta-blockers for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2005; (4): CD003566.
18. Boros PW, Franczuk M, Wesołowski S. Zasady interpretacji wyników badania spirometrycznego. *Pneumonol Alergol Pol* 2004; 72 (Supl. 2): 19-28.
19. Gondorowicz K, Sergiejko Z. Procedury wykonywania badań. Akceptowalność i powtarzalność pomiarów. *Pneumonol Alergol Pol* 2004; 72 (Supl. 2): 16-8.
20. Kowalski J, Koziorowski A, Radwan L. Ocena czynności płuc w chorobach układu oddechowego. *Wydawnictwo Borgis,* Warszawa 2004.

Ocena zachowania się wybranych wskaźników spirometrycznych u starszych chorych z niewydolnością serca

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Streszczenie

Wstęp: Związek między niewydolnością serca i dysfunkcją układu oddechowego jest przedmiotem intensywnych badań. Coraz ważniejsze miejsce zajmuje – obok oceny klinicznej, echokardiograficznej, radiologicznej czy wreszcie biochemicznej – ocena wydolności układu oddechowego metodą spirometryczną. U chorych z obrzękiem płuc opisywano upośledzenie wentylacji o cechach restrykcji, które może się pojawić nawet przed wystąpieniem objawów klinicznych czy cech radiologicznych. Niewydolności serca najczęściej towarzyszą łagodne lub umiarkowane cechy obturacji, zwłaszcza jeśli u chorych współistnieją przewlekłe schorzenia układu oddechowego.

Cel: Ocena wybranych spirometrycznych parametrów wydolności układu oddechowego u chorych ze świeżo rozpoznaną lub leczoną niewydolnością serca.

Metodyka: Do badania zakwalifikowano grupę 110 chorych z niewydolnością serca – w tym 74 (67,3%) mężczyzn. U wszystkich wykonano badanie echokardiograficzne oraz badanie spirometryczne z próbą rozkurczową. Niewydolność serca stwierdzono, opierając się na wytycznych *European Society of Cardiology* oraz kryteriach Framingham. Badanie spirometryczne i próbę rozkurczową, czyli ponowne badanie spirometryczne po 20 min od podania 200 μg wziewnego salbutamolu, wykonano zgodnie z zaleceniami *European Respiratory Society* z 1993 r. Kryteria wyłączające stanowiły: astma oskrzelowa, przewlekła obturacyjna choroba płuc, gruźlica i choroba nowotworowa w wywiadzie. Średni wiek badanej populacji wyniósł 68,5±8,9 roku. Aktywne palenie tytoniu w wywiadzie podawało 60 (54,5%) osób. Wśród chorób towarzyszących nadciśnienie tętnicze występowało u 86,4%, cukrzyca typu 2 u 20,9%, zawał mięśnia sercowego (MI) w wywiadzie u 49,1% badanych. W leczeniu, w chwili włączenia do badania, beta-blokery stosowało 54,5%, inhibitory enzymu konwertującego angiotensynę (ACE-I) 84,5%, diuretyki 83,6%, blokery kanału wapniowego 30%, kwas acetylosalicylowy 92,7% osób. W badaniu echokardiograficznym frakcję wyrzutową lewej komory (LVEF) <45% wykazano u 74 (67,3%) osób. Stwierdzono, że chorzy z obniżoną LVEF charakteryzowali się częstszym występowaniem MI w wywiadzie oraz częstszym przyjmowaniem ACE-I, diuretyków i blokerów kanału wapniowego, w grupie tej było także istotnie więcej osób ciągle palących papierosy. Porównania parametrów spirometrycznych dokonano w grupach chorych z LVEF >45% i LVEF ≤45%. Przy użyciu pakietu Statistica 6.0, we wstępnej analizie statystycznej wykorzystano testy normalności, test t-Studenta, test U Manna-Whitneya, test χ^2 oraz analizę korelacji Pearsona. W celu wyodrębnienia czynników niezależnie powiązanych z analizowanymi zmiennymi wykorzystano wieloczynnikową analizę regresji.

Wyniki: Wszystkie analizowane parametry spirometryczne były wyraźnie niższe u chorych z niewydolnością serca. U chorych z upośledzoną kurczliwością lewej komory stwierdzono umiarkowane i średnie zaburzenia wentylacji o typie mieszanym (ze średnią odwracalnością obturacji wynoszącą 15,03% badanej w stosunku do wartości początkowej), w tej grupie spełnione było także kryterium objętościowe, tj. średni przyrost natężonej objętości wydechowej pierwszosekundowej w próbie rozkurczowej wynosił 410 ml. W grupie chorych z zachowaną czynnością skurczową komory test odwracalności obturacji był ujemny, tzn. średni przyrost natężonej objętości wydechowej pierwszosekundowej wyniósł 5,71% (160 ml). Po przeprowadzeniu analizy statystycznej wykazano, iż parametrami wpływającymi na natężoną objętość wydechową pierwszosekundową były wiek, palenie tytoniu oraz LVEF. Pozostałe zależności nie osiągnęły znamienności statystycznej.

Wnioski: U chorych ze skurczową niewydolnością serca, niezależnie od stosowanego leczenia, obserwowano mieszane zaburzenia oddechowe z komponentą obturacyjną i dodatnią próbę rozkurczową. Obok upośledzonej czynności skurczowej lewej komory, na pogorszenie parametrów oddechowych w badanej grupie chorych wpływ miały także starszy wiek i palenie tytoniu.

Słowa kluczowe: spirometria, niewydolność serca

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