Relationship of respiratory muscle strength, pulmonary function, and functional capacity with quality of life in patients with atrial fibrillation

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Abstract

Objective: To examine the relationship of pulmonary parameters and functional capacity with quality of life (QoL) in patients with atrial fibrillation (AF).

Methods: Thirty-six patients with chronic AF were included in this cross-sectional study. QoL was assessed with the Medical Outcomes Survey 36-item Short Form (SF-36) and Minnesota Living with Heart Failure Questionnaire (MLHFQ). Respiratory muscle strength and pulmonary function were also measured. Functional capacity was assessed with the 6-min walk test (6MWT). The Borg CR10 Scale was used to determine the resting dyspnea and fatigue levels.

Results: The SF-36 physical component summary score was correlated with the maximum inspiratory pressure ($r = 0.517$), maximum expiratory pressure ($r = 0.391$), 6MWT distance ($r = 0.542$), resting Borg dyspnea score ($r = -0.692$), and resting Borg fatigue score ($r = -0.727$). The MLHFQ total score was correlated with the maximum inspiratory pressure ($r = -0.542$), maximum expiratory pressure ($r = -0.384$), 6MWT distance ($r = -0.535$), resting Borg dyspnea score ($r = 0.641$), and resting Borg fatigue score ($r = 0.703$). The resting Borg fatigue score was the significant independent predictor of the SF-36 physical component score and the MLHFQ total score.

Conclusion: Respiratory muscle strength, functional capacity measured with the 6MWT, and resting symptoms including dyspnea and fatigue may have an impact on QoL in patients with AF.

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Introduction

Atrial fibrillation (AF) is the most common cardiac rhythm disturbance. It affects 1% to 2% of the general population, and its prevalence increases with advancing age. The underlying mechanism of AF is multifactorial; therefore, its management can be complex and difficult.[1] Although the symptoms of AF, including exercise intolerance, dyspnea, and fatigue, range from nonexistent to severe and differ among patients, the quality of life (QoL) of affected patients is usually impaired.[2–6]

AF also affects the ventilatory function of the lungs.[7,8] Some studies have shown that the forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1) are lower in patients with AF than in those without AF.[9,10] Additionally, one study showed respiratory muscle weakness in patients with AF.[8] However, the pulmonary function of these patients and its contribution to the disease burden has not been extensively investigated.

QoL in patients with AF is reportedly associated with symptom severity scores,[6] the physical activity level, the New York Heart Association (NYHA) functional class,[11] and depression and anxiety symptoms.[12,13] Because possible pulmonary impairment has been reported, we believe that to examine QoL, patients with AF should be assessed in a comprehensive manner that includes assessment of both pulmonary function and respiratory muscle strength. Therefore, this study was performed to analyze the relationship of QoL with pulmonary function, respiratory muscle strength, and functional capacity in patients with AF.

Patients and methods

Study design and population

A cross-sectional study was designed. Thirty-six patients with chronic AF were recruited from the rhythm management polyclinic in a university hospital according to the following criteria: continuous chronic AF of >6 months in duration, a left ventricular ejection fraction of >40%, and a NYHA functional class of I or II. The exclusion criteria were the presence of any chronic lung diseases, recent coronary bypass surgery, previous heart valve surgery, rheumatic valvular heart disease, acute myocardial infarction, and the presence of a pacemaker. This study was approved by the ethics committee of a university hospital, and all participants included in the study provided written informed consent before data collection.

QoL

QoL was measured with the generic Medical Outcomes Survey 36-item Short Form (SF-36) and disease-specific Minnesota Living with Heart Failure Questionnaire (MLHFQ). The SF-36 is a valid and reliable 36-item questionnaire that is widely used to measure QoL in the general population. It yields an 8-scale profile of functional health and well-being scores as well as two summary scores of physical and mental health. A higher score indicates better QoL.[14] The MLHFQ is a disease-specific questionnaire comprising 21 items rated on 6-point Likert scales. It yields a total score as well as physical (8 items) and emotional (5 items) dimension scores. A higher score indicates poorer QoL.[15] The MLHFQ was developed

for patients with heart failure but is also widely used in patients with other cardiac diseases, including AF.[2]

Pulmonary function and respiratory muscle strength

Pulmonary function was measured with a spirometer (SpiroUSB; CareFusion, San Diego, CA, USA) according to the criteria of the American Thoracic Society (ATS) and European Respiratory Society (ERS).[16] The FVC, FEV_1, peak expiratory flow, and forced expiratory flow at 25% to 75% of the pulmonary volume were measured and are expressed as percentages of the predicted values. Respiratory muscle strength was measured by the maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) using a hand-held respiratory pressure meter (MicroRPM; CareFusion) according to the ATS/ERS guideline.[17] The maximum value of three efforts that varied by <5% was recorded for the MIP and MEP.

Functional capacity and resting symptoms

Functional capacity was measured with the 6-min walk test (6MWT) according to the guideline of the ATS.[18] The test was repeated twice with a 30-min recovery period between the tests, and the higher 6-min walk distance (6MWD) was recorded. The resting dyspnea and resting fatigue levels were assessed with the Borg CR10 Scale. The anchors were 0 for no fatigue or shortness of breath and 10 for maximum fatigue or shortness of breath.[19]

Statistical analysis

Statistical analyses were performed using the SPSS 20.0 statistical program (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation, ordinal variables are expressed as median [minimum–maximum], and categorical variables are expressed as percentages. The data distribution was assessed with the Kolmogorov–Smirnov test, Lilliefors test, and Shapiro–Wilk test. Pearson correlation analysis was used for normally distributed continuous data, and Spearman correlation analysis was used for ordinal or non-normally distributed data to assess the relationship of QoL scores with the pulmonary function, functional capacity, and clinical features. A linear regression model was used to assess which predictors contributed to the prediction of the SF-36 physical component summary and MLHFQ total score. QoL, pulmonary function, and functional capacity were compared between patients with a NYHA class of I and II using the independent-samples t-test or Mann–Whitney U test depending on the distribution properties of the data. A p value of <0.05 was considered statistically significant for all analyses.

Results

The patients' demographics, clinical features, and test results are shown in Table 1. Correlations of pulmonary function and functional capacity with the SF-36 summary scores and MLHFQ scores are shown in Table 2.

The SF-36 physical component summary score was strongly correlated with the resting Borg fatigue score; moderately correlated with the MIP, 6MWD, and resting Borg dyspnea score; and weakly correlated with the MEP (p < 0.05).

The MLHFQ total and physical dimension scores were strongly correlated with the resting Borg fatigue score; moderately correlated with the MIP, 6MWD, and resting Borg dyspnea score; and weakly correlated with the MEP (p < 0.05). The MLHFQ emotional dimension score was weakly correlated with the MIP and 6MWD (p < 0.05).

Table 1. Demographics, clinical features, and test results of the patients ($n = 36$)

Demographics and clinical features	
Age (years)	66.60 ± 7.59
Sex	
Female / male	18 (50) / 18 (50)
Ejection fraction (%)	58.71 ± 3.38
Body mass index (kg/m^2)	30.92 ± 4.45
New York Heart Association functional class	
I / II	17 (47) / 19 (53)
Resting heart rate (beats/min)	99.00 ± 12.13
Resting Borg dyspnea score	3 [0–7]
Resting Borg fatigue score	3 [0–7]
Short Form-36	
Physical component summary score	40.17 ± 7.89
Mental component summary score	44.46 ± 10.61
Minnesota Living with Heart Failure Questionnaire	
Total score	24.99 ± 11.29
Physical dimension score	16.06 ± 6.49
Emotional dimension score	6.63 ± 4.29
Pulmonary function	
FVC (pred%)	92.61 ± 16.70
FEV$_1$ (pred%)	92.73 ± 16.20
FEF$_{25\text{-}75}$ (pred%)	81.30 ± 23.22
PEF (pred%)	80.94 ± 21.70
Maximum inspiratory pressure (cmH$_2$O)	66.31 ± 17.44
Maximum expiratory pressure (cmH$_2$O)	91.81 ± 20.31
Functional capacity	
6-min walk test (m)	391.00 ± 65.4

Data are presented as mean $\pm$ standard deviation, n (%), or median [min–max]
FEF$_{25\text{-}75}$: forced expiratory flow at 25% to 75% of the pulmonary volume; FEV$_1$: forced expiratory volume in 1 s; FVC: forced vital capacity; PEF: peak expiratory flow.

The patients' spirometric parameters were >80% of the predicted values; i.e., the parameters were normal and were not correlated with any of the QoL scores.

A linear regression model including the variables MIP, 6MWD, and resting Borg fatigue score was the best model for predicting the SF-36 physical component score and MLHFQ total score, explaining 59% and 54% of the variance, respectively ($p < 0.001$). The resting Borg fatigue score was the significant independent predictor for the SF-36 physical component score and MLHFQ total score. Patients with higher resting Borg fatigue scores had poorer QoL (Table 3).

The comparison of QoL between the patients with a NYHA class of I and II is shown in Table 4. Compared with patients with a NYHA class of I, those with a NYHA class of II had significantly poorer physical and mental component QoL scores and all subgroup scores except "Social Functioning" and "Role Limitations-emotional" of the SF-36 as well as significantly poorer total, physical, and emotional dimension scores of the MLHFQ ($p < 0.05$). No significant differences in the spirometric

Table 2. Correlations of pulmonary function and functional capacity with SF-36 summary scores and MLHFQ scores (n = 36)

	MIP	MEP	FVC	FEV_1	FEF_{25-75}	PEF	6MWD	Resting Borg dyspnea	Resting Borg fatigue
SF-36									
PCS	0.517**	0.391*	0.228	0.240	0.126	0.138	0.542**	−0.692**	−0.727**
MCS	0.171	0.151	−0.305	−0.265	−0.057	−0.187	0.106	−0.490	−0.183
MLHFQ									
Total	−0.542**	−0.384*	−0.062	−0.052	−0.231	0.172	−0.535**	0.641**	0.703**
PDS	−0.531**	−0.407*	−0.051	−0.041	−0.230	0.164	−0.598**	0.501*	0.703**
EDS	−0.462*	−0.316	0.076	0.034	−0.200	0.071	−0.311	0.205	0.314

Data are presented as correlation coefficients (r).
*$p < 0.05$; **$p < 0.01$
EDS: emotional dimension score; FEV_1: forced expiratory volume in 1 s; FEF_{25-75}: forced expiratory flow at 25% to 75% of the pulmonary volume; FVC: forced vital capacity; MEP: maximum expiratory pressure; MIP: maximum inspiratory pressure; MLHFQ: Minnesota Living with Hearth Failure Questionnaire; MSC: mental component summary score; PCS: physical component summary score; PDS: physical dimension score; PEF: peak expiratory flow; SF-36: Short Form-36; 6MWD: 6-minute walk distance.

Table 3. Multivariate linear regression for prediction of SF-36 physical component score and MLHFQ total score (n = 36)

Dependent variable	Independent variable	R^2	Adjusted R^2	Standardized β	p
PCS of SF-36	Resting Borg fatigue	0.64	0.59	−0.613	0.000*
	MIP			0.185	0.261
	6MWD			0.015	0.939
Total score of MLHFQ	Resting Borg fatigue	0.59	0.54	0.499	0.005*
	MIP			−0.220	0.208
	6MWD			−0.79	0.699

*Statistically significant.
MLHFQ: Minnesota Living with Heart Failure Questionnaire; MIP: maximum inspiratory pressure; PCS: physical component score of Short Form-36; SF-36: Short Form-36

values, MIP, or MEP were observed between classes I and II. The 6MWD was significantly higher in patients with a NYHA class of I than II (428 m vs. 374 m, respectively; p < 0.05).

Discussion

In the present study, the respiratory muscle strength, especially the MIP of patients with AF, was significantly correlated with the SF-36 physical component score and MLHFQ physical and mental dimension scores. The patients' spirometric values were normal (>80% of the predicted values) and did not have an influence on the QoL scores in either questionnaire. The functional capacity as measured by the 6MWT was correlated with the SF-36 physical component score and MLHFQ physical and mental dimension scores. An important finding is that compared with the other measurements, the resting Borg fatigue score had the strongest correlation with the

Table 4. Comparison of quality of life scores between patients in New York Heart Association functional class I and II

	NYHA class I (n = 17)	NYHA class II (n = 19)	p-value
Short Form-36			
Physical functioning	77.67 ± 9.03	54.35 ± 16.14	0.000*
Role limitations – physical	54.17 ± 32.61	36.01 ± 29.17	0.047*
Bodily pain	71.20 ± 14.12	51.96 ± 20.34	0.007*
General health	57.33 ± 14.87	40.38 ± 21.66	0.021*
Vitality	58.00 ± 12.36	31.73 ± 20.38	0.000*
Social functioning	84.13 ± 15.99	73.74 ± 27.10	0.123
Role limitations – emotional	70.00 ± 26.88	53.66 ± 44.87	0.102
Mental health	71.33 ± 10.57	54.10 ± 17.73	0.005*
Physical component summary	44.10 ± 6.34	36.24 ± 9.44	0.010*
Mental component summary	49.15 ± 10.74	39.77 ± 10.40	0.023*
Minnesota Living with Heart Failure Questionnaire			
Total score	17.37 ± 6.88	30.44 ± 10.74	0.001*
Physical dimension score	12.07 ± 4.36	18.92 ± 6.31	0.002*
Emotional dimension score	3.63 ± 2.48	8.76 ± 4.06	0.010*

Data are presented as mean ± standard deviation.
*Statistically significant.
NYHA: New York Heart Association

QoL scores. Although the predictive factors for QoL in patients with AF have been previously investigated, this was the first study to investigate how QoL is influenced by pulmonary function, respiratory muscle strength, and functional capacity as measured with the 6MWT.

According to the ATS/ERS guideline,[17] MIP values of <80 cmH$_2$O are abnormal and indicate inspiratory muscle weakness. In the present study, the mean MIP value of patients with AF was 66.31 ± 17.44 cmH$_2$O, indicating inspiratory muscle weakness. Inspiratory muscle weakness may negatively influence QoL in patients with AF, as indicated by the correlation between inspiratory muscle strength and the QoL scores. Thus, we hypothesize that exercise training focusing on the inspiratory muscles may improve the QoL of patients with AF. This hypothesis is consistent with the findings of Cahalin et al.,[20] who reported that inspiratory muscle training improved QoL

in patients with heart disease and heart failure. Similar studies are needed for patients with AF.

We found no relationship between the spirometric values and QoL in the present study. Previous studies have reported an influence of FVC and FEV$_1$ on QoL in patients with heart failure[21] and chronic obstructive pulmonary disease.[22] The reason for the lack of such a correlation between the spirometric values and QoL in the present study may be that our patients had normal spirometric values.

Tsounis et al.[11] and Arribas et al.[23] both reported that patients with AF with a higher NYHA functional class had worse scores in several QoL measures. These findings are consistent with our results: our patients with an NYHA class of II had worse scores than those with an NYHA class of I in almost all SF-36 subgroups and for all MLHFQ scores ($p < 0.05$). Besides the NYHA functional classification, we also found a significant

correlation of the functional capacity as measured with the 6MWT with the SF-36 physical component score and MLHFQ total and physical dimension scores. This is an important finding because the 6MWT is frequently used in cardiac rehabilitation programs.[24] The 6MWD of patients with AF can be improved with aerobic exercise training,[25] Qi Gong training (Traditional Chinese Medicine),[26] and inspiratory muscle training.[8] Considering the relationship between the 6MWT performance and QoL, it may be assumed that by improving the 6MWD, the patients' QoL may also improve. This assumption is supported by the findings of Osbak et al.[25] They reported significant improvements in the 6MWD and QoL scores on both the SF-36 and MLHFQ questionnaires with aerobic exercise training.

In the present study, the resting Borg dyspnea and fatigue scores had the strongest correlation with QoL. This finding is not surprising because the literature clearly shows that in patients with AF, QoL decreases as symptom severity increases.[6,27] Drug trials have shown that patients' QoL can increase with improvements in AF-related symptoms.[28,29] Additionally, Smith et al.[30] reported that symptom control is a key factor when determining QoL in patients with AF. However, the literature contains no exercise training studies that focus on improving symptoms to increase QoL in these patients. Therefore, future studies are needed.

Patients with AF have poorer QoL than individuals without AF. The purpose of the present study was to determine whether respiratory function contributes to their QoL. Thus, we measured pulmonary function within a group of patients with AF and correlated our measures with the QoL measures in this patient population. The QoL in a control group of patients without AF may or may not be correlated with pulmonary function, but this would not pertain to the interaction between pulmonary function and AF on QoL and could mask our results because they pertain to improvements in QoL of patients with AF. The main limitation of this study is that the sample size was relatively small and the results may not be representative for all patients with AF. Nevertheless, the literature shows evidence of impairments in pulmonary function and respiratory muscle strength of patients with AF; therefore, the impact of these impairments on QoL should be investigated in future studies with larger sample sizes.

Conclusion

Several factors that influence QoL in patients with AF have been defined in the literature. In the present study, we found that the respiratory muscle strength, especially the strength of the inspiratory muscles, and the functional capacity of patients with AF may also be related to QoL. Future studies should consider the inclusion of respiratory muscles and functional capacity in their assessments when examining the QoL in these patients. The fatigue level of the patients was also an independent predictor for the QoL measures in our study, which emphasizes the importance of symptom control in the management of QoL in patients with AF.

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