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FVC, FEV_1, FEV_1/FVC % and their Relationship with EF% in Patients with Chronic Heart Failure

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Abstract:

Background: Chronic heart failure (CHF) causes multiple lung complications and lung functions are reduced in CHF patients. Objective: To observe FVC, FEV_1, FEV_1/FVC% and their relationship with EF% in patients with chronic heart failure. Methods: This cross sectional study was conducted in the Department of Physiology of Bangabandhu Sheikh Mujib Medical University (BSMMU), Shahbag, Dhaka, during 2016. For this, 60 diagnosed stable male, aged 35-65 years CHF patients were randomly selected from the Cardiology Department of BSMMU, Dhaka. On the basis of staging of the disease (Stage C) and New York Heart Association (NYHA) functional classification, the study subjects were divided into two groups, 30 patients of NYHA Class- I and 30 patients of NYHA class –II. Thirty (30) apparently healthy Age, Sex and BMI matched subjects were taken as control. To assess the ventilatory function, Forced vital capacity (FVC), Forced expiratory volume in 1st second (FEV_1), Forced expiratory ratio (FEV_1/FVC%) of all subjects were measured by a portable Digital Spirometer. Again, Ejection fraction (EF%) ranged (≥35% to ≤50%) were measured by Echocardiogram to observe left ventricular function of the heart. For statistical analysis, Independent sample't' test and Pearson's correlation co-efficient test was performed by using SPSS for windows version-16 & $p \leq 0.05$ was accepted as level of significance. Results: The mean percentage of predicted values of FVC and FEV_1 were significantly lower but FEV_1/FVC% was significantly higher in CHF patients comparison to the healthy control. All the study variables were significantly lower in patients of NYHA class–II as compared to patients of NYHA class–I. 73.33% CHF patients had restrictive, 10.00% small airway obstruction and 16.67% combined restrictive and small airway obstruction feature. In addition, FVC and FEV_1 ($p<0.05$) was positively and FEV_1/FVC% ($p<0.05$) negatively correlated with EF% in chronic heart failure patients. Conclusion: Left ventricular dysfunction may be silently associated with decrease ventilatory function mainly restrictive type of pulmonary disorder.

Key words: Chronic heart failure, Lung function parameters, Ejection fraction (EF%)

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Introduction:

Heart failure is one of the significant global public health problems and leading causes of premature morbidity and mortality as well as a chronic disease that has been found worldwide, affecting nearly 23 million people globally.[1] In the USA, annually 1.5 to 2% of the total population has been diagnosed as incidental cases of heart failure which is about 550,000.[2,3,4]

Heart failure (HF) is a complex clinical syndrome that arises secondary to abnormalities of cardiac structure and/or function (inherited or acquired) that impair the ability of the left ventricle to fill or eject blood.[5]

Heart failure has been classified, according to New York Heart Association (NYHA) functional classification: NYHA class I, without any symptoms attributable to heart disease, and those patients who have mild, moderate and severe symptoms were said to have NYHA classes II, III and IV respectively.[6]

The development of heart failure has been categorized into 4 stages of the disease, Stage A: it is characterized by high risk for development of heart failure without structural heart disease or symptoms of HF. Stage B: it presents structural heart disease but without sign or symptoms of HF. Stage C: it presents structural heart disease with prior

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or current symptoms of HF. Stage D: it is a refractory heart failure requiring specialized interventions.[5, 7]

As per ESC guidelines revealed that most common causes of heart failure are coronary artery disease, respiratory diseases, diabetes, hypertension, dyslipidemia, valve disease, atrial fibrillation.[8]

Pulmonary and cardiac systems are hemodynamically and mechanically co related due to heart and lungs both reside in a closed thoracic cavity. Mild to moderate changes in lung function in chronic heart failure are mainly restrictive and some extent obstructive changes because of respiratory muscle weakness, pulmonary hypertension, reduction in lung diffusing capacity, changes in lung fluid balance and chronic neurohumoral changes.[9]

Force vital capacity (FVC) is a predictor of respiratory muscle strength. Framingham heart study, suggested that low FVC is the predictor of severity of heart failure.[10]

Several epidemiological studies revealed that reduced lung function as measured by Force vital capacity (FVC), Forced expiratory volume in 1st second (FEV_1) and Force expiratory ratio (FEV_1/FVC%) was associated with an increased risk of cardiovascular morbidity and mortality.[9-13]

Along with other lung function parameters, low value of FEV_1 related to reduced left ventricular ejection fraction that responsible for incident of heart failure.[1]

Some studies revealed that abnormal lung function in heart failure was associated with pulmonary congestion, pulmonary hypertension, pulmonary edema as well as increased bronchial conductance and obstruction.[14,15]

Apostolo et al. (2012) studied that in CHF involved heart, lungs, kidney, neurohormonal mechanism, mitochondria, peripheral and respiratory muscles, all together related to gas exchange capacity and alteration of respiratory mechanics.[16]

Studies observed that no significant difference in FEV_1, FFV_1/FVC ratio, hospital admission and mortality rates among the patients having CHF with wheezing (cardiac asthma) and chronic heart failure.[17]

So, this study has been designed to observe FVC, FEV_1, FEV_1/FVC% and their relationship with EF% in Bangladeshi chronic heart failure patients.

Methods:

Study design

This cross sectional study was carried out in the Department of Physiology, BSMMU, Dhaka from March 2015 to February 2016. Study protocol was approved by Institutional Review Board (IRB) of BSMMU.

Study procedure

A total 90 male subjects were randomly selected, 60 were stable aged 35-65 years CHF patients as study group and 30 age, sex and BMI matched apparently healthy subjects were taken as control group for comparison. Study subjects as per the American Heart Association (AHA) guidelines, 2013 based on staging of the disease (Stage C) and New York Heart Association (NYHA) functional classification were further divided into two groups, patients of NYHA Class- I and patients of NYHA class–II with 30 patients in each group.

Patients were selected from the Cardiology Department of BSMMU, Dhaka seeking for medical follow up and patients who get diagnosed as chronic heart failure at this health center. Control group were selected from different area of Dhaka city by personal contact.

All the subjects with history of acute or chronic lung & chest wall diseases e.g. pneumonia, COPD, pneumothorax, malignancy etc, angina, acute myocardial infarction, valvular surgery, alcohol users, smokers and for study group with NYHA class- III and IV patients were excluded from the study.

After selection of the subject, objectives and the study procedure were explained in details to the subjects and the accompanying relatives. They were encouraged for voluntary participation. If they agree to participate at their free will, informed written consent was obtained in a prescribed form. During the study period the patients were treated with standard optimized medications for heart failure and they were clinically stable as determined by clinicians. A detail personal, medical, family, socioeconomic, occupational, dietary and drug history was taken. After thorough physical examinations all the information were recorded in a preformed standard questionnaire.

For confirmation of the recent condition of heart failure patients an echocardiogram was done by cardiologist to measure the left ventricular ejection fraction (LVEF). Anthropometric measurement including height and weight was taken and BMI was calculated from measured height and weight. For the assessment of lung function, all the subjects were examined for FVC, FEV_1 and FEV_1/FVC% by using a PONY FX portable Digital Spirometer.

Statistical analysis

All the data were expressed as mean ± SE (Standard Error) and also as percent. For data analysis, Statistical Packages

for Social Sciences (SPSS) for windows version 16 was used. Data analysis was done by One-way ANOVA, Independent sample't' test and correlation analysis was done by Pearson's correlation co-efficient test. P value d"0.05 was accepted as statistical significant.

Results:

General characteristics are presented in the Table I. In this study, the mean percentages of predicted values of FVC and FEV_1 were significantly lower ($p<0.001$) in study group than those of control. Again, the mean percentage of predicted value of FEV_1/FVC% was significantly higher ($p<0.001$) in study group in comparison to that of control (Table II).

EF% was significantly lower ($p<0.001$) in NYHA class-I and NYHA class-II of chronic heart failure patients than that of healthy control (Table III).

In this study, among 30 patients with chronic heart failure of NYHA class-I, 7 (23.33%), 10 (33.33%) and 13 (43.33%) patients were in 35 to 40%, 41 to 45% and 46 to 50% of EF range, respectively.

Similarly, among 30 patients with chronic heart failure of NYHA class-II, 10 (33.33%), 8 (26.67%) and 12 (40.00%) patients were in 35 to 40%, 41 to 45% and 46 to 50% of EF range, respectively (Table IV).

Among the CHF patients, 73.33% patients had restrictive, 10.00% small airway obstruction and 16.67% patients showed features of both restrictive and obstructive type of lung dysfunction (Figure 1).

The mean percentages of predicted values of FVC and FEV_1 were found positively but FEV_1/FVC% were found negatively correlated with EF% in CHF patients (Figure 2, 3, 4) and the relation was statistically significant ($p<0.05$).

Table-I

General characteristics of the subjects in different groups (n=90)

Parameters	Group A(n=30)	Group B_1(n=30)	Group B_2(n=30)	P value
Age (years)	50.03±1.26	51.70±1.62	50.33±1.24	0.801^{ns}
BMI (Kg/m^2)	22.38±0.26	22.21±0.25	21.51±0.25	0.951^{ns}
Pulse rate (beats/min)	76.57±0.98	91.90±1.05	95.97±0.76	0.000^{***}
SBP (mmHg)	121.0±1.80	128.0±1.06	129.0±1.08	0.000^{***}
DBP (mmHg)	75.67±0.92	81.67±1.05	83.50±1.20	0.000^{***}

BMI= Body Mass Index, SBP= Systolic Blood Pressure, DBP= Diastolic Blood Pressure
Data were expressed as mean ± SE (Standard Error).
Statistical analysis were done by Independent sample't' test and One way ANOVA
Group A : Apparently healthy subjects (Control group)
Group B_1 : Diagnosed patients with CHF of NYHA Class- I (Study)
Group B_2 : Diagnosed patients with CHF of NYHA Class -II (Study)
***** : Significant ($p\leq0.001$)
** : Significant ($p\leq0.01$)
ns : non significant ($p>0.05$)
n : number of subjects.

Table-II

Percentages of predicted values of FVC, FEV_1 and FEV_1/FVC% in different groups (n=90)

Parameters	Group A (n=30)	Group B_1 (n=30)	Group B_2 (n=30)	P value
FVC (L)	97.13±1.32	73.07±0.79	54.83±1.92	0.000^{***}
FEV_1 (L)	93.90±1.33	75.50±1.41	49.10±1.32	0.000^{***}
FEV_1/FVC%	94.17±1.71	106.30±1.65	99.00±0.73	0.000^{***}

Data were expressed as mean ± SE (Standard Error).
Statistical analysis were done by Independent sample't' test and One way ANOVA

Table-III

Mean values of Ejection Fraction (EF %) in different groups (n=90)

Group	EF %
Group A (n=30)	65.20±0.42***
Group B_1 (n=30)	43.67±0.88***
Group B_2 (n=30)	43.30±0.89***

Data were expressed as mean ± SE (Standard Error).
Statistical analysis were done by One way ANOVA
*** p<0.001

Table-IV

Frequency percentage of study subjects by EF % in different groups (n=60)

EF (%)	Groups			
	B_1 (n=30)		B_2 (n=30)	
	F	(%)	F	(%)
35-40	7	(23.33%)	10	(33.33%)
41-45	10	(33.33%)	8	(26.67%)
46-50	13	(43.33%)	12	(40.00%)

Data were expressed as mean ± SE (Standard Error).
F : Frequency
% : Percentage
EF : Ejection fraction

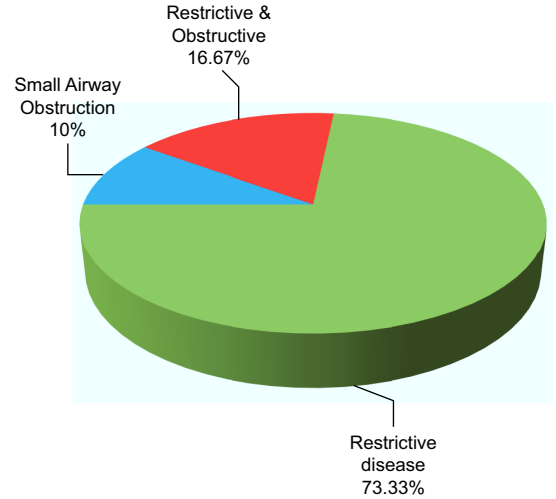

Fig.-1: *Frequency distribution of pulmonary disorders in CHF patients (n=60)*

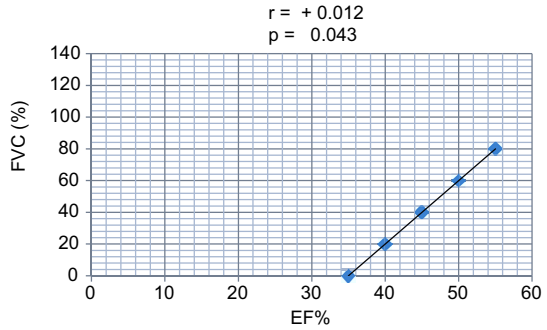

Fig.-2: *Positive correlation of percentages of predicted value of FVC with EF% in CHF patients (n=60)*

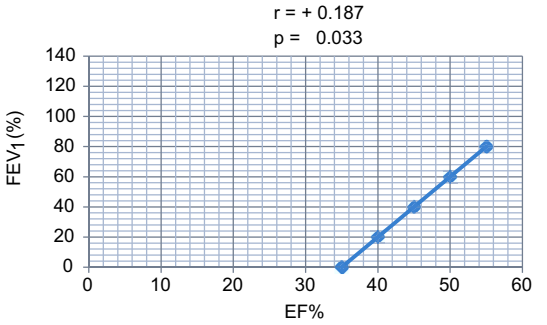

Fig.-3: *Positive correlation of percentages of predicted value of FEV_1 with EF% in CHF patients (n=60)*

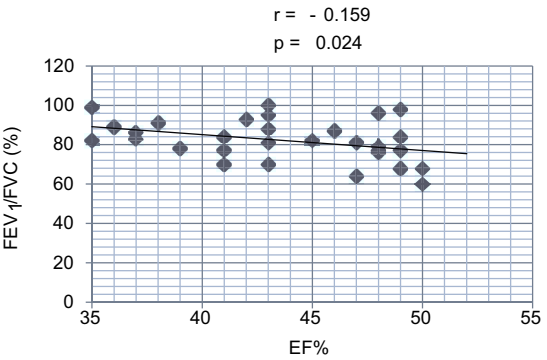

Fig.-4: *Negative correlation of percentages of predicted value of FEV1/FVC% with EF% in CHF patients (n=60)*

Discussion:

In this study, the mean percentages of predicted values of FVC and FEV_1 in CHF patients were significantly lower than the control. Evidence from similar studies were also support this observation.[14-21] But some studies do not support this. Some investigators of other countries reported FEV_1/FVC% was found significantly higher in CHF patients than healthy control.[14]

Also, reported by other researcher FEV_1/FVC% was found lower values and the differences among the different groups were statistically non significant.[12, 22]

In the present study, all the patients had abnormal lung function that assessed by portable digital spirometer. Restrictive type of pulmonary disorder was found in 73.33%, obstructive in 10.00% and both restrictive and obstructive in 16.67% of these CHF patients. But, several investigators of different countries have reported, different types of ventilatory defects in this group of patients, though the frequency distribution was not similar to the present study.[23-25]

In the present study, 27(90.00%) patients with chronic heart failure of NYHA class-I presented with this restrictive pattern of ventilatory defect. Among them 15 (55.56%), 7 (25.92%) and 5 (18.52%) patients were presented with mild, moderate and moderately severe restriction, respectively.

However, 26 patients with chronic heart failure of NYHA class-II, presented with this restrictive pattern of ventilatory defect. Within them, 4 (15.38%), 5(19.23%), 11 (42.31%) and 6 (23.08%) patients were presented with moderate, moderately severe, severe and very severe restriction, respectively.

The correlation analysis in the study EF% was positively correlated with FVC ($p<0.05$), FEV_1 ($p<0.05$) but FEV_1/FVC% ($p<0.05$) showed negative relationship in CHF patients. This observation may suggest association of deterioration of pulmonary function with lower values of ejection fraction in the heart. The similar findings also observed by some other investigators.[1, 25]

Literature survey suggested different possible mechanism related with lung abnormalities to chronic heart failure.[24, 26]

It has been suggested that reduced respiratory muscle perfusion due to low cardiac output is one of the potential contributor factor of respiratory muscle weakness which results in decrement of forcefully ventilatory variables which might be the cause of restrictive pulmonary disorder.[22, 27]

Research evidences proposed that restrictive and obstructive features of lung in these patients may related to energy deficit, cardiac and skeletal myopathy, alterations of respiratory mechanics, gas exchange capacity, interstitial edema, alveolar-capillary membrane hydrostatic injury, altered alveolar fluid, increased venous capacitance with elevated pulmonary capillary pressure that lead to pulmonary edema.[24-33]

Researcher Figueroa and Peters (2006) found that the relationship between decrement of different ventilatory variables and ejection fraction in chronic heart failure patients may be due to systolic and diastolic dysfunction as a consequence of reduced cardiac output.[34] Francis and Tang (2003) suggested that any sort of myocardial injury (Coronary artery disease, poorly controlled hypertension, valvular heart disease, primary "idiopathic" cardiomyopathy, genetic cardiomyopathies, and restrictive cardiomyopathies) might be the cause of systolic as well as diastolic dysfunction due to lymphocytic inflammatory myocarditis or infiltrative disorders.[35]

The exact mechanism for this change is not clear but all of these above mentioned factors may cause overall respiratory dysfunction as well as alteration in ventilatory variables in stable chronic heart failure patients of this study.

Conclusion:

From this study, it may be concluded that alteration of ventilatory function mainly restrictive type of pulmonary disorder associated with left ventricular dysfunction and this alteration in chronic heart failure patients may be occur silently.

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