SS-158 Is Diaphragm Thickness Associated With Respiratory Muscle Strength And Endurance İn Patients With Heart Failure?

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Introduction: Heart failure (HF) is a clinical syndrome which is associated with histologic, morphologic, and metabolic changes in skeletal muscle (1). Regardless of left ventricular ejection fraction, respiratory muscle dysfunction is one of the features of HF (1). Both limb and respiratory muscle strength may alter in patients with HF, but respiratory muscle strength seems to be more affected than limb muscle strength (2). Furthermore, decreased respiratory muscle endurance has been well reported in HF (3). One study has reported that diaphragm dysfunction assessed by ultrasonography may reflect inspiratory muscle strength in HF (4). However, the association between diaphragm thickness and respiratory muscle endurance remains unknown. Therefore, this study aimed to investigate correlations between diaphragm thickness, respiratory muscle strength, and endurance in patients with HF.

Methods: This cross-sectional study included patients with diagnosed HF and reduced ejection fraction (HFrEF), aged between 45 years to 80 years, and clinically stable. Patients were excluded if they had congenital heart disease, severe valvular heart disease and pulmonary disease, neurological disease or orthopedic problems that may limit their mobility. Demographic and clinical features of patients were recorded. Diaphragm thickness was assessed with ultrasonography at different lung volumes (residual volume, DT_{RV}; functional residual capacity, DT_{FRC}; total lung capacity, DT_{TLC}) (4). To measure respiratory muscle strength, maximal inspiratory pressure (MIP) and maximal expiratory pressures (MEP) were assessed using a mouth pressure device (Micro RPM, Micro Medical Ltd., Rochester, Kent, UK). Respiratory muscle endurance was evaluated with sustainable inspiratory pressure (SIP) and incremental threshold loading (ITL) tests using a pressure threshold device (POWERbreathe ®). To evaluate SIP, the load was set at 60% of MIP and patients performed breathing via threshold device for as long as they were able to do until 10 min. To evaluate ITL, the load was started at 20% of MIP and patients performed breathing via threshold device for 2 min. Every 2 minutes load was increased by 20 %. The duration of the SIP test and the highest ITL load which participants were able to sustain for at least 1 min were recorded (5). Analysis was performed using SPSS version 26. The continuous variables were presented as mean and standard deviation (SD) while categorical variables were presented as numbers and percentages. The normality was assessed using the skewness kurtosis test. The correlations between the variabilities were analyzed with Spearman's rank-order or Pearson product-moment correlation tests according to the distribution of normality. Statistical significance was set at 0.05.

ResultsThis study enrolled 44 patients with HFrEF, of whom eight were female. Demographic and clinical features are presented in Table 1. The mean age and ejection fraction of patients were 62.0 years and 29.4%, respectively. Twenty-eight patients were NYHA class II, while sixteen patients were NYHA class III.

Table 1. Demographic and clinical parameters in HFrEF

Parameters	Mean ± SD (n=44)
Age, years	62.0 ± 9.1
Gender, male	36 (81.89)
BMI, kg/m^2	27.8 ± 3.8
EF, %	29.4 ± 6.7
NYHA class	
II	28 (63.6)
III	16 (36.4)
$DT_{RV,}$ mm	2.18 ± 0.58
$DT_{FRC,}$ mm	2.84 ± 1.05
$DT_{TLC,}$ mm	3.97 ± 1.00
MIP, cmH_2O	59.90 ± 19.07
MEP, cmH_2O	104.97 ± 29.12
SIP, s	115.00 ± 62.74
ITL, %	49.09 ± 15.22

BMI, body mass index; EF, ejection fraction; NYHA, New York Heart Association; DT_{RV}, diaphragm thickness at residual volume; DT_{FRC}, diaphragm thickness at functional residual capacity; DT_{TLC}, diaphragm thickness at total lung capacity; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure; SIP, sustainable inspiratory pressure; ITL, incremental threshold loading.

The correlations between the variables are given Table 2. DT_{RV}, DT_{FRC}, and DTTLC correlated with MIP (DT_{RV}, r = 0.421, p = 0.006; DT_{FRC}, r = 0.509, p = 0.001; DT_{TLC}, r = 0.443, p = 0.003). DT_{RV}, DT_{FRC}, and DTTLC did not correlate with MEP, SIP, and ITL ($p > 0.05$).

Table 2. Correlations between diaphragm thickness, respiratory muscle strength and endurance

	DT_{RV}		DT_{FRC}		DT_{TLC}	
	rho	*p*	*rho*	*p*	*rho*	*p*
MIP	0.421	**0.006***	0.509	**0.001***	0.443	**0.003***
MEP	0.038†	0.810	0.180	0.253	0.296†	0.051
SIP	0.112	0.479	0.090	0.570	0.005	0.975
ITL	-0.067	0.671	0.022	0.892	0.139	0.368

DT_{RV}, diaphragm thickness at residual volume; DT_{FRC}, diaphragm thickness at functional residual capacity; DT_{TLC}, diaphragm thickness at total lung capacity; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure; SIP, sustainable inspiratory pressure; ITL, incremental threshold loading.
*Statistically significant difference (p<0.05)
† r Pearson's correlation coefficient

Discussion: This study indicated that diaphragm thickness was correlated with inspiratory muscle strength. Diaphragm muscle thickness did not correlate with expiratory muscle strength and respiratory muscle endurance in patients with HFrEF.

Diaphragm thickness measured by ultrasound has been shown to be impaired in patients with HFrEF (4). Histologic abnormalities such as reduced capillary density, muscle fiber atrophy, decreased electromyographic activity and metabolic changes such as impairment of oxidative capacity and hypoperfusion may occur in muscle tissue in HF (1). All these factors lead to altered respiratory muscle strength as well as limb muscle strength. In addition, circulating pro-inflammatory cytokines have been found to be associated with respiratory muscle dysfunction in patients with HFrEF (1). We found a correlation between diaphragm thickness and inspiratory muscle strength in line with the literature (4).

To the best of our knowledge, this is the first study investigating the correlation between diaphragm thickness and respiratory muscle endurance in patients with HFrEF. We did not find any correlation between diaphragm thickness and respiratory muscle endurance. However, future studies should comprehensively evaluate the correlation between diaphragm thickness and respiratory muscle endurance with larger sample size and all HF phenotypes.

Conclusions: Diaphragm thickness is associated with inspiratory muscle strength but not respiratory muscle endurance in patients with HFrEF. Since inspiratory muscle training is evidence-based therapy to improve inspiratory muscle strength, it may help to counteract diaphragm dysfunction in patients with HFrEF.

Keywords: diaphragm thickness, respiratory muscle endurance, respiratory muscle strength

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