Original Article

Echocardiographic Parameters Associated with Bendopnea in Patients with Systolic Heart Failure

Alireza Rostamzadeh, MD, Kamal Khademvatani, MD, Shahyad Salehi, MD, Mir Hossein Seyyed Mohammadzad, MD, Mehdi Khani, MD*, Mojgan Hajahmadipour Rafsanjani, MD, Behnam Askari, MD, Behzad Rahimi, MD, Zahra Mostafavi, MD, Reza Hajizadeh, MD

Department of Cardiology, Urmia University of Medical Sciences, Urmia, Iran.

Received 08 June 2022; Accepted 27 September 2022

Abstract

Background: *Bendopnea, defined as dyspnea while bending, can be observed in patients with heart failure (HF). In this study, we investigated the frequency of this symptom in patients with systolic HF and its association with echocardiographic parameters.*

Methods: *In this study, patients with left ventricular ejection fraction (LVEF) ≤45% and decompensated HF referred to our clinics were prospectively recruited. All the patients were examined by cardiologists for collecting data on the presence of bendopnea and baseline characteristics. They also underwent electrocardiographic and echocardiographic examinations. All findings were compared between the patients with or without bendopnea.*

Results: *A total of 120 patients at a mean age of 65.19±12.62 years were evaluated, and 74.8% were men. Bendopnea was observed in 44.2% of the patients. The etiology of HF was ischemic in most patients (81.9%), and the functional class of most patients (85.9%) was III or IV. The mortality rate at the 6-month follow-up was comparable between the patients with or without bendopnea (6.1% vs 9.5%; P=0.507). The waist circumference (odds ratio [OR], 1.037, 95% confidence interval [CI], 1.005 to 1.070; P=0.023), paroxysmal nocturnal dyspnea (OR, 0.338, 95% CI, 0.132 to 0.866; P=0.024), and right atrial size (OR, 1.084, 95% CI, 1.002 to 1.172; P=0.044) were associated with bendopnea.*

Conclusion: *Bendopnea can be frequently found among patients with systolic HF. This phenomenon is associated with obesity and baseline symptoms of patients and right atrial size upon echocardiographic examinations. It can help clinicians with the risk stratification of HF patients.*

J Teh Univ Heart Ctr 2022;17(4):223-229

This paper should be cited as: Rostamzadeh A, Khademvatani K, Salehi S, Seyyed Mohammadzad MH, Khani M, Hajahmadipour Rafsanjani M, et al. Echocardiographic Parameters Associated with Bendopnea in Patients with Systolic Heart Failure. J Teh Univ Heart Ctr 2022;17(4):223-229.

Keywords: *Heart failure; Bendopnea; Echocardiography; Right atrium*

*Corresponding Author: ***Mehdi Khani,*** *Urmia University of Medical Sciences, Seyyed-Al Shohada Hospital, 17 Shahrivar Boulevard, Urmia, Iran. 5718748983. Tel: +98 44 32375909. Fax: +98 44 32372917. E-mail: dr.khmehdi@gmail.com.*

Introduction

Cardiovascular diseases (CVDs) are one of the leading causes of mortality and morbidity, responsible for 1 in every 2 to 3 deaths (1 death every 40 seconds) in the United States.[1, 2] Heart failure (HF), the common endpoint of CVDs,[3] is estimated to affect more than 8 million people (prevalence =1 in every 33 individuals) in the United States by 2030.[4] The increasing prevalence and mortality rates of HF have prompted enormous studies to identify its specific symptoms, risk factors, and survival rate.[5, 6]

Several symptoms have been identified for HF, varying based on the disease type (systolic or diastolic HF) and disease chronicity.[7] Dyspnea in different forms, such as orthopnea, paroxysmal nocturnal dyspnea (PND), exertional dyspnea, and shortness of breath, is the principal symptom of acute HF.[8] However, symptoms are nonspecific findings and can be observed in pulmonary arterial hypertension and respiratory problems, hence the efforts to determine more specific symptoms.[9] Bendopnea, also called "flexo-dyspnea",[10] is a recently-assigned symptom of HF and is defined as shortness of breath after 30 seconds of bending forward observed in patients with systolic[11] and decompensated HF.[12] Its occurrence could be due to the increased abdominal and chest pressure by bending and imposing greater pressure on the diseased heart.[13] Its development is associated with worse cardiac function and higher disease severity in patients with chronic HF with reduced left ventricular ejection fraction (LVEF),[14] and it is reported with a higher incidence in patients with advanced or decompensated HF, leading to higher mortality rates.[15, 16] Some researchers suggest that this symptom is not specific to HF and may be observed in the general population[17] and patients with other cardiac[18] or noncardiac diseases.[19] On the other hand, others suggest that bendopnea can be used to differentiate HF from respiratory or coronary artery diseases.[20]

As this symptom has been only introduced within recent years, there are few studies addressing its clinical significance and different aspects of this symptom, such as its association with the hemodynamics and prognosis of patients.[21-25] Therefore, in this study, we investigated the frequency of bendopnea in a population of patients with systolic HF and its association with clinical findings, electrocardiographic features, echocardiographic parameters, readmission rates, and 6-month mortality.

Methods

The present cross-sectional study recruited all patients who were referred to Seyyed-Al Shohada Hospital (a tertiary heart center in Urmia) from June 20th through December 20th, 2017, with decompensated HF. The study protocol was approved by the Ethics Committee of Urmia University of Medical Sciences (Ethics code: 96-09-32-3030). In addition, all the participants signed an informed consent form.

The study sample was selected using the convenient sampling method from patients with LVEF ≤45%, patients diagnosed with systolic HF, and patients admitted with decompensated HF during the study period and without primary valvular diseases or respiratory problems. Any patients who could not bend forward because of any muscular or joint diseases or any other problems were excluded.

The researcher recorded the patients' baseline characteristics based on an investigator-designed questionnaire. All symptoms of HF, including orthopnea, PND, and edema, in conjunction with the functional class, were determined according to the New York Heart Association (NYHA) classification and were recorded in a checklist. For the evaluation of bendopnea, the patients were asked to bend forward for 30 seconds while seated on a chair and report any dyspnea or shortness of breath. If the patients developed headache, fatigue, or symptoms of syncope during the bendopnea test, they were asked to stop bending and were referred for appropriate care. These patients were excluded from the study. The severity of bendopnea during daily activities (eg, wearing shoes) was also enquired from the patients, and its effect on daily activities were recorded as none, mild, moderate, or severe. The grading of severity was defined as requiring several maneuvers to perform routine activities (mild), inability to perform daily activities (moderate), and inability to carry out activities at all (severe).

All the patients were examined via echocardiography by a cardiac specialist using a Vivid S6 echocardiography (GE Medical Systems, Milwaukee, WI, USA) device. Echocardiographic parameters, including the end-diastolic volume of the LV, left atrial size, mitral regurgitation severity, pulmonary artery pressure, right ventricular size and severity of failure (function), diastolic HF, right atrial size, pulmonary capillary wedge pressure, inferior vena cava size and (inspiratory) collapse, tricuspid annular plane systolic excursion, right ventricular peak systolic myocardial velocity, LV outflow tract velocity time integral, LV outflow tract diameter, and cardiac output, were recorded in the checklist. Furthermore, blood samples were taken from all the patients and sent to the hospital's laboratory for the measurement of serum parameters, including hemoglobin, creatinine, and sodium. The glomerular filtration rate was calculated using the Cockcroft–Gault formula and reported as mL/min/1.73 m^2.

The etiology of HF was considered ischemic or nonischemic according to the report of coronary angiography. The length of hospital stay at first admission to our center was recorded. All the patients were followed

up by telephone interviews 6 months after discharge, and their cardiac-related mortality was recorded.

Descriptive results were presented as numbers (percentages) for categorical variables and the mean ± the standard deviation (SD) for continuous variables. For the comparison of variables between the patients with or without bendopnea, the t and χ^2 tests were used to compare the continuous and categorical variables, respectively. To find variables associated with bendopnea and after defining the variables as dependent or independent, we employed a multivariable logistic regression analysis. All variables with a P value <0.05 in univariable analysis and age and sex were entered into a multivariable model. The statistical analysis was carried out using the SPSS statistics software for Windows version 23.0 (IBM Co, Armonk, NY, USA). A P value <0.05 was considered statistically significant.

Results

The present study evaluated 120 patients, of whom 74.2% were men. The mean of the patients' age was 65.19±12.62 years. Bendopnea was present in 53 patients (44.2%). The duration of starting bendopnea after bending was 13.5±6.21 seconds. The mean waist circumference was higher in the patients with bendopnea than in those without it (P=0.02). The etiology of HF was ischemic in most of the patients (81.9%). A few cases (12.1%) had atrial fibrillation (AF). The functional class of most patients (85.9%) was III or IV (31.9% and 54.6%, respectively), while only 5.3% of the patients had functional class I. All the baseline characteristics are summarized in Table 1 and Table 2.

As shown, the right atrial size was significantly greater in the patients with bendopnea than in those without it

Table 1. Baseline characteristics of the patients in groups with or without bendopnea*

Variables	Total (n=120)	Patients with Bendopnea (n=53)	Patients without Bendopnea (n=67)	P
	65.19±12.62	66.30±11.00	64.31±13.80	0.394
Sex				
Male	74.2	66.2	80.6	0.070
Female	25.8	34.6	19.4	
Height (cm)	162.86±9.03	162.57±9.88	163.09±8.36	0.754
Weight (kg)	71.84±15.49	73.79±17.73	70.30±13.40	0.221
Body mass index (kg/m^2)	27.12±5.47	27.88±5.84	26.52±5.13	0.178
Waist circumference (cm)	98.47±14.02	101.79±16.31	95.81±11.35	0.020
Hip circumference (cm)	99.02±8.29	100.55±8.61	97.81±7.88	0.072
Waist-to-hip ratio	0.99 ± 0.09	1.0 ± 0.10	0.98 ± 0.06	0.056
Etiology of HF				0.235
Ischemic	81.9	87.1	78.3	
Nonischemic	18.1	13.4	22.2	
Length of hospital stay (day)	6.65±4.13	6.79±3.40	6.54±4.65	0.738

*Data are presented as mean±SD or n (%).
GFR, Glomerular filtration rate; HF, Heart failure; NYHA, New York heart association functional class; PND, Paroxysmal nocturnal dyspnea

Table 2. Association between symptoms, laboratory findings, and bendopnea*

Variables	Total	Patients with Bendopnea	Patients without Bendopnea	P
NYHA				
I	5.3	0	9.1	
II	8.8	4.3	11.9	0.069
III	31.9	32.6	31.3	
IV	54.2	63.3	47.8	
Orthopnea	80.8	86.8	76.1	0.140
PND	66.7	79.2	56.7	0.009
Peripheral edema	41.7	54.7	31.3	0.010
Laboratory Findings				
Serum sodium (meq/L)	139.17±4.36	139.04±5.45	139.28±3.26	0.767
Serum hemoglobin (mg/dL)	12.29±2.12	12.05±1.90	12.48±2.27	0.280
Creatinine (mg/dL)	1.49±0.86	1.44±0.40	1.52±1.10	0.633
GFR (mL/min/1.73 m^2)	54.64±27.15	51.62±18.48	57.04±32.40	0.289

*Data are presented as mean±SD or n (%).
NYHA, New York heart association functional class; PND, Paroxysmal nocturnal dyspnea; GFR, Glomerular filtration rate

Table 3. Left ventricular echocardiographic parameters in the patients with or without bendopnea*

Variables	Total (n=120)	Patients with Bendopnea (n=53)	Patients without Bendopnea (n=67)	P
Heart rate (beats/min)	82.93±16.90	82.81±16.07	83.01±17.64	0.948
Cardiac output (mL/min)	3780.54±141.85	3767.60±1501.92	3790.78±1353.44	0.929
Mitral Regurgitation				
Mild	55.2	52.9	56.9	0.909
Moderate	25.9	27.5	24.6	0.909
Severe	19.2	19.6	18.5	0.727
LV ejection fraction (%)	21.29±7.54	21.04±7.55	21.50±7.57	0.741
LV diastolic dysfunction				
Mild	72.7	65.9	77.6	0.443
Moderate	11.1	14.6	8.2	0.443
Severe	16.7	19.5	14.3	0.297
LVEDV (cc)	158.06±63.21	159.30±67.06	157.07±60.49	0.849
LVOT VTI (cm/s)	14.82±5.01	14.70±5.23	14.92±4.87	0.815
LVOT-D (cm)	2±0.23	1.99±0.22	2.01±0.25	0.652

*Data are presented as mean±SD or n (%).
LV, Left ventricular; LVEDV, Left ventricular end-diastolic volume; LVOT VTI, Left ventricular outflow tract velocity time integral; LVOT-D, Left ventricular outflow tract diameter

Table 4. Right ventricular echocardiographic parameters in the patients with or without bendopnea*

Variables	Total	Patients with Bendopnea	Patients without Bendopnea	P
RV size (cm)	29.62±6.01	30.21±6.46	29.15±5.64	0.341
RVsm	10.85±3.65	10.35±3.67	11.24±3.61	0.186
RV systolic dysfunction				
Mild	43.1	37.9	48.3	0.727
Moderate	41.4	44.8	37.9	0.726
Severe	15.5	17.2	13.8	0.466
TRG (mmHg)	20.93±13.56	22.66±14.43	19.52±12.74	0.213
TAPSE	16.39±5.59	15.74±4.34	16.91±6.39	0.253
Pulmonary artery pressure (mmHg)	27.60±14.66	29.55±15.32	25.97±14.00	0.192

*Data are presented as mean±SD or n (%).
RV, Right ventricular; RVsm, Right ventricular peak systolic myocardial velocity; TRG, Tricuspid regurgitant gradient; TAPSE, Tricuspid annular plane systolic excursion

Table 5. Atrial and diastolic function echocardiographic parameters in the patients with or without bendopnea*

Variables	Total	Patients with Bendopnea	Patients without Bendopnea	P
Left atrial size (cm^2)	20.97±6.62	21.89±7.70	20.25±5.58	0.178
Right atrial size (cm^2)	15.85±5.68	17.16±6.78	14.81±4.42	0.024
E	0.68±0.33	0.70±0.36	0.67±0.30	0.618
E′	4.61±1.88	4.41±1.45	4.78±2.16	0.291
E/E′	0.154±0.09	0.21±0.29	1.63±5.68	0.077
A	0.70±0.24	0.68±0.25	0.72±0.23	0.439
Deceleration time (ms)	223.09±108.90	221.42±115.35	224.36±104.62	0.886
IVC size (cm)	1.74±1.79	1.52±0.59	1.90±2.32	0.251
IVC collapse				
>50%	84.7	79.2	89.2	0.317
30-50%	2.5	3.8	1.5	0.318
<30%	12.7	17.5	9.2	0.157

*Data are presented as the mean ± the standard deviation (SD) or numbers (%).
E, Peak early diastolic mitral velocity; E′, Peak early velocity; A, Peak late diastolic mitral velocity; IVC, Inferior vena cava

Table 6. Logistic regression results for finding the predictors of bendopnea

	OR	95% CI	P
Age (y)	1.007	0.974 – 1.042	0.673
Male	2.281	0.861 – 6.044	0.097
Waist circumference	1.037	1.005 – 1.070	0.023
PND	0.338	0.132 – 0.866	0.024
Peripheral edema	0.650	0.279 – 1.514	0.318
RA size	1.084	1.002 – 1.172	0.044

PND, Paroxysmal nocturnal dyspnea; RA, Right atrium

(P=0.02). The other results of echocardiographic parameters and their associations with bendopnea are gathered in tables 3 to 5. At the 6-month follow-up, 9 patients (7.5%) had cardiac-related mortality; nonetheless, the mortality rate was comparable between the patients with or without bendopnea (6.1% vs 9.5%, respectively; P=0.507).

When we compared the 2 groups of subjects with or without 6-month mortality, none of the baseline characteristics and echocardiographic findings was significantly different between the groups. Nevertheless, the rates of functional classes III and IV were significantly higher among the subjects with 6-month mortality than that in those who were alive at the 6-month follow-up. (Data are not presented.)

Based on the multivariable logistic regression analysis, waist circumference (OR, 1.037, 95% CI, 1.005 to 1.070; P=0.023), PND (OR, 0.338, 95% CI, 0.132 to 0.866; P=0.024), and right atrial size (OR, 1.084, 95% CI, 1.002 to 1.172; P=0.044) were associated with bendopnea (Table 6).

Discussion

In the present study, the incidence of bendopnea was investigated in a group of patients with systolic HF (EF ≤45%), admitted with decompensated HF at a mean age of 65.19 years and male dominance. The results showed that bendopnea was positive in 53 out of 120 patients (44.2%), occurring at a mean interval of 13.55 seconds. Our findings confirmed bendopnea as a significant sign in patients with decompensated systolic HF. Bendopnea has been reported by only a few studies as it is a newly suggested symptom. It was first described as flexo-dyspnea in 2013.[10] One year later, it was termed "bendopnea", with a definition of shortness of breath by bending forward among patients with systolic and advanced HF following daily activities requiring leaning forward, such as putting on shoes or socks.[11]

Thibodeau et al[11] investigated this sign in 102 patients with systolic HF referred for right-heart catheterization and reported that 28% of the patients had bendopnea at a median onset of 8 seconds (75th percentile of 11 seconds). Although the prevalence of bendopnea in their study was lower than that in ours (44.2%), which could be due to more advanced disease in our study population (patients with decompensated HF), the time of the onset of bendopnea was slightly shorter in their study than in ours.

An assessment of 192 patients with chronic HF and reduced EF showed positive bendopnea in 38.5% of the patients at a mean onset time of 8.62 seconds.[14] Then again, the prevalence of bendopnea was lower than that in the present study, while the onset time was shorter. These differences in the results of studies are probably because of the difference in patients' characterization as we investigated patients admitted with decompensated HF, while the abovementioned studies included stable patients.[11, 14]

Concordant with the present study, Baeza–Trinidad et al[16] investigated 250 patients admitted with decompensated HF and reported bendopnea in 48.8% of the patients at a mean onset of 13.4 seconds. The incidence rate and the mean onset time of their study are similar to those reported in the present study, which both confirm a high rate of bendopnea in patients with decompensated HF.

In addition to the prevalence of bendopnea, its time of occurrence is also of great importance as shorter-onset bendopnea is associated with a higher mortality rate.[11,16] In the present study, the general mortality rate of the patients during a 6-month follow-up was 8% and not different between patients with and without bendopnea, nor was the readmission rate or the duration of hospital admissions, while some researchers have suggested worse clinical outcomes in patients with bendopnea.[26]

In the next step, we investigated the differences in other clinical variables between the patients with and without bendopnea, and the results showed a higher prevalence of PND, peripheral edema, and syncope in patients with bendopnea. Orthopnea and PND are the most prevalent symptoms of patients with systolic HF and are considered valuable symptoms with high specificity for the diagnosis of HF.[27, 28]

Baeza–Trinidad et al[16] also reported higher frequencies of orthopnea, PND, oliguria, edema, elevated jugular venous pressure, abdominal fullness, and worse functional classes in their study on patients admitted with decompensated HF. The higher prevalence rates of PND and edema, reported by Baeza–Trinidad and colleagues, chime in with the results of our study. Further, the measurement of anthropometric variables in the present study showed a higher mean waist

circumference in patients with bendopnea, one of the 2 variables with significant effects on bendopnea in the final regression model. These results suggest the effect of higher abdominal pressure on the occurrence of bendopnea; nevertheless, the mean body mass index and the mean hip circumference were not different between patients with and without bendopnea. No difference in body mass index between patients with and without bendopnea was also reported by Baeza–Trinidad and colleagues.[16] Other researchers have also described the association between bendopnea and patients' hemodynamics and increased filling pressure while bending in patients with a reduced cardiac index,[11] as well as increased pulmonary capillary wedge pressure and the resolution of bendopnea following diuresis.[10] In contrast, we did not find any differences in functional class, the serum profile of the sodium level, and renal parameters (creatinine and glomerular filtration rate) between patients with or without bendopnea.

We further investigated the electrocardiographic and echocardiographic parameters of our study population. Cardiac rhythm, especially AF, is of great significance in patients with HF, and patients with concomitant AF and HF have a higher mortality rate.[27]

The mutual relationship between AF and HF causes patients with AF to develop HF, while structural changes in HF can also result in the development of AF.[28] The results of our study showed that about 12% of the patients had AF, but there was no difference in cardiac rhythm between the groups. Studying the echocardiographic parameters also showed no difference in the EF of the patients with or without bendopnea, in line with the results of the study by Baeza–Trinidad et al.[16] Nevertheless, Niu et al[14] reported lower EF and 6-minute walking distance in patients with bendopnea than in those without bendopnea, contrary to the results of the present study. This difference could be because of different patients' conditions, as Niu and colleagues did not investigate patients with decompensated HF. The only echocardiographic variable that was different between patients with and without bendopnea in the present study was the mean right atrial size, which was significantly higher in the patients with bendopnea and was 1 of the 2 factors with significant effects on bendopnea in our regression model. This finding confirms the results reported by Thibodeau et al[11] on the higher right atrial and wedge pressure in patients with bendopnea. Baeza-Trinidad et al[16] also reported enlargement of both atria, as well as higher pulmonary artery systolic pressure in patients with bendopnea.

The present study had the salient strength of examining the association between a wide range of clinical and echocardiographic findings and bendopnea in a sample of patients with decompensated HF. However, this study has some limitations, such as lack of a matched control group to compare the incidence of bendopnea with the general population or patients with other cardiac diseases. We excluded patients with respiratory diseases to omit its effect on bendopnea, but we did not investigate the comorbid cardiac diseases of the patients, which may also affect bendopnea. Nonetheless, given the paucity of studies on bendopnea, it is not yet clear which cardiac diseases can cause this symptom. Furthermore, we only followed up patients for 6 months, while longer follow-ups may reveal more accurate results regarding the impact of bendopnea on long-term outcomes. Further large-scale studies with long-term follow-ups are warranted to evaluate the clinical significance of bendopnea in our daily practice.

Conclusion

Bendopnea is observed in about half of patients with decompensated HF and can be a significant sign of this disease. Accordingly, bendopnea is associated with structural changes during HF and can indicate patients' conditions. This newly suggested symptom should be further studied to investigate its clinical significance and its accuracy for the risk stratification of patients and its possible efficacy in the prediction of outcomes.

Acknowledgments

We appreciate the assistance of all the participants in this study and all the staff members of Seyyed-Al Shohada Hospital. This study was approved and supported by Urmia University of Medical Sciences.

References

1. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, Chiuve SE, Cushman M, Delling FN, Deo R, de Ferranti SD, Ferguson JF, Fornage M, Gillespie C, Isasi CR, Jiménez MC, Jordan LC, Judd SE, Lackland D, Lichtman JH, Lisabeth L, Liu S, Longenecker CT, Lutsey PL, Mackey JS, Matchar DB, Matsushita K, Mussolino ME, Nasir K, O'Flaherty M, Palaniappan LP, Pandey A, Pandey DK, Reeves MJ, Ritchey MD, Rodriguez CJ, Roth GA, Rosamond WD, Sampson UKA, Satou GM, Shah SH, Spartano NL, Tirschwell DL, Tsao CW, Voeks JH, Willey JZ, Wilkins JT, Wu JH, Alger HM, Wong SS, Muntner P; American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics-2018 Update: A Report From the American Heart Association. Circulation 2018;137:e67-e492.
2. Hosseini SK, Naghshtabrizi B, Emami F, Yazdi A, Naghshtabrizi N, Zebarjadi S. Very Early Discharge of Patients with ST-Segment-Elevation Myocardial Infarction after Primary Percutaneous Coronary Intervention. J Tehran Heart Cent 2021;16:113-118.
3. Groenewegen A, Rutten FH, Mosterd A, Hoes AW. Epidemiology of heart failure. Eur J Heart Fail 2020;22:1342-1356.
4. Heidenreich PA, Albert NM, Allen LA, Bluemke DA, Butler J, Fonarow GC, Ikonomidis JS, Khavjou O, Konstam MA, Maddox

TM, Nichol G, Pham M, Piña IL, Trogdon JG; American Heart Association Advocacy Coordinating Committee; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular Radiology and Intervention; Council on Clinical Cardiology; Council on Epidemiology and Prevention; Stroke Council. Forecasting the impact of heart failure in the United States: a policy statement from the American Heart Association. Circ Heart Fail 2013;6:606-619.
5. Komanduri S, Jadhao Y, Guduru SS, Cheriyath P, Wert Y. Prevalence and risk factors of heart failure in the USA: NHANES 2013 - 2014 epidemiological follow-up study. J Community Hosp Intern Med Perspect 2017;7:15-20.
6. Mahmood SS, Levy D, Vasan RS, Wang TJ. The Framingham Heart Study and the epidemiology of cardiovascular disease: a historical perspective. Lancet 2014;383:999-1008.
7. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, Falk V, González-Juanatey JR, Harjola VP, Jankowska EA, Jessup M, Linde C, Nihoyannopoulos P, Parissis JT, Pieske B, Riley JP, Rosano GM, Ruilope LM, Ruschitzka F, Rutten FH, van der Meer P; Authors/Task Force Members; Document Reviewers. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. Eur J Heart Fail 2016;18:891-975.
8. McKelvie RS, Moe GW, Ezekowitz JA, Heckman GA, Costigan J, Ducharme A, Estrella-Holder E, Giannetti N, Grzeslo A, Harkness K, Howlett JG, Kouz S, Leblanc K, Mann E, Nigam A, O'Meara E, Rajda M, Steinhart B, Swiggum E, Le VV, Zieroth S, Arnold JM, Ashton T, D'Astous M, Dorian P, Haddad H, Isaac DL, Leblanc MH, Liu P, Rao V, Ross HJ, Sussex B. The 2012 Canadian Cardiovascular Society heart failure management guidelines update: focus on acute and chronic heart failure. Can J Cardiol 2013;29:168-181.
9. Malekpour Alamdari N, Bayat F, Bakhtiyari M, Noori M. Effects of Weight Loss on Echocardiographic Parameters 1 Year after Sleeve Gastrectomy. J Tehran Heart Cent 2019;14:128-133.
10. Brandon N, Mehra MR. "Flexo-dyspnea": A novel clinical observation in the heart failure syndrome. J Heart Lung Transplant 2013;32:844-845.
11. Thibodeau JT, Turer AT, Gualano SK, Ayers CR, Velez-Martinez M, Mishkin JD, Patel PC, Mammen PP, Markham DW, Levine BD, Drazner MH. Characterization of a novel symptom of advanced heart failure: bendopnea. JACC Heart Fail 2014;2:24-31.
12. Baeza-Trinidad R, Mosquera-Lozano JD, Gómez-Del Mazo M, Ariño-Pérez de Zabalza I. Evolution of bendopnea during admission in patients with decompensated heart failure. Eur J Intern Med 2018;51:e23-e24.
13. Brandon N. Characterization of a novel symptom of advanced heart failure: bendopnea. JACC Heart Fail 2014;2:540.
14. Niu F, Ma Q, Liu NR, Chen JH, Ren J. [Clinical value of bendopnea in chronic heart failure patients with reduced left ventricular ejection fraction]. Zhonghua Xin Xue Guan Bing Za Zhi 2017;45:126-129.
15. Dominguez-Rodriguez A, Thibodeau JT, Abreu-Gonzalez P, Ayers CR, Jimenez-Sosa A, Aranda JM Jr, Drazner MH. Association Between Bendopnea and Key Parameters of Cardiopulmonary Exercise Testing in Patients With Advanced Heart Failure. J Card Fail 2016;22:163-165.
16. Baeza-Trinidad R, Mosquera-Lozano JD, El Bikri L. Assessment of bendopnea impact on decompensated heart failure. Eur J Heart Fail 2017;19:111-115.
17. Baeza-Trinidad R, Isaula-Jimenez O, Peinado-Adiego C, Mosquera-Lozano JD. Prevalence of bendopnea in general population without heart failure. Eur J Intern Med 2018;50:e21-e22.
18. Dominguez-Rodriguez A, Thibodeau JT, Ayers CR, Jimenez-Sosa A, Garrido P, Montoto J, Prada-Arrondo PC, Abreu-Gonzalez P, Drazner MH. Impact of bendopnea on postoperative outcomes in patients with severe aortic stenosis undergoing aortic valve replacement. Interact Cardiovasc Thorac Surg. 2018;27:808-812.
19. Handa A, Agarwal R. Allergic bronchopulmonary aspergillosis causing bendopnea. Lung India 2017;34:304-305.
20. Martínez Cerón DM, Garcia Rosa ML, Lagoeiro Jorge AJ, de Andrade Martins W, Tinoco Mesquita E, Di Calafriori Freire M, da Silva Correia DM, Kang HC. Association of types of dyspnea including 'bendopnea' with cardiopulmonary disease in primary care. Rev Port Cardiol 2017;36:179-186.
21. Karauzum K, Karauzum I, Kilic T, Sahin T, Baydemir C, Baris Argun S, Celikyurt U, Bildirici U, Agir A. Bendopnea and Its Clinical Importance in Outpatient Patients with Pulmonary Arterial Hypertension. Acta Cardiol Sin 2018;34:518-525.
22. Larina VN, Bart BY, Chukaeva II, Karpenko DG, Zacharova MI, Kulbachinskaya OM. Bendopnea: Association With Echocardiographic Features and Clinical Outcomes in Elderly Patients With Chronic Heart Failure. Kardiologiia 2018;58:36-44.
23. Pranata R, Yonas E, Chintya V, Alkatiri AA, Budi Siswanto B. Clinical significance of bendopnea in heart failure-Systematic review and meta-analysis. Indian Heart J 2019;71:277-283.
24. Thibodeau JT, Jenny BE, Maduka JO, Divanji PH, Ayers CR, Araj F, Amin AA, Morlend RM, Mammen PP, Drazner MH. Bendopnea and risk of adverse clinical outcomes in ambulatory patients with systolic heart failure. Am Heart J 2017;183:102-107.
25. Ekundayo OJ, Howard VJ, Safford MM, McClure LA, Arnett D, Allman RM, Howard G, Ahmed A. Value of orthopnea, paroxysmal nocturnal dyspnea, and medications in prospective population studies of incident heart failure. Am J Cardiol 2009;104:259-264.
26. Vijayakrishnan R, Steinhubl SR, Ng K, Sun J, Byrd RJ, Daar Z, Williams BA, deFilippi C, Ebadollahi S, Stewart WF. Prevalence of heart failure signs and symptoms in a large primary care population identified through the use of text and data mining of the electronic health record. J Card Fail 2014;20:459-464.
27. Mamas MA, Caldwell JC, Chacko S, Garratt CJ, Fath-Ordoubadi F, Neyses L. A meta-analysis of the prognostic significance of atrial fibrillation in chronic heart failure. Eur J Heart Fail 2009;11:676-683.
28. Kotecha D, Piccini JP. Atrial fibrillation in heart failure: what should we do? Eur Heart J 2015;36:3250-3257.