Research Article / Araştırma Makalesi

Relationship Between Coronary Collateral Circulation and The Presence of Bendopnea in Patients with Ischemic Low Ejection Fraction Heart Failure

İskemik Düşük Ejeksiyon Fraksiyonlu Kalp Yetmezliği Olan Hastalarda Koroner Kollateral Dolaşım ile Bendopne Varlığı Arasındaki İlişki

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Abstract

Background: Coronary collateral circulation(CCC) is a physiological protective mechanism that develops as a result of critical coronary artery stenosis and ischemia. Bendopnea, shortness of breath upon bending forward, is linked to poor cardiac index, increased pulmonary capillary wedge pressure, and coronary artery disease. This study aims to investigate the relationship between coronary collateral circulation and the presence of bendopnea in patients with ischemic low ejection fraction heart failure.
Materials and Methods: The cross-sectional study screened 1024 patients diagnosed with heart failure with low ejection fraction after coronary angiography between January 2023 and January 2024, and 259 met the inclusion criteria. Inclusion criteria for the study were defined as having stable coronary artery disease and low ejection fraction heart failure (LVEF<40%) Patients were categorized into bendopnea+ and bendopnea- groups. Rentrop classification was used as a basis for the evaluation of CCC
Results: There were 158 patients (mean age: 74.1±12.9 years, % 66.4 male) in the bendopnea+ group, while there were 101 patients (mean age: 67.2±14.2 years, %70.2 male) in the bendopnea- group. Bendopnea+ patients were older and had a higher number of NYHA class 3-4 individuals(p<0.001). NT-proBNP(p=0.001) and uric acid levels(p=0.001) were significantly higher in the bendopnea+ group. The Gensini score(p=0.001) and poor collateral circulation(p=0.001) were significantly higher in the bendopnea+ group. Systolic pulmonary artery pressure (sPAP) was notably higher in the bendopnea+ group (p=0.001). Regression analyses identified age(OR: 1.355 %95 CI:1.212-1.517 p=0.001), NT-proBNP(OR: 1.252 %95 CI:1.195-1.412 p=0.001), NYHA class 3-4(OR: 1.245 %95 CI:1.195-1.412 p=0.001),, Gensini score(OR: 1.328 %95 CI:1.213-1.515 p=0.001), and poor collateral circulation(OR: 1.318 %95 CI:1.162-1.441 p=0.001) as independent risk factors for bendopnea. **Conclusions:** The study concludes that insufficient coronary collateral circulation is an independent risk factor for bendopnea in ischemic heart failure patients.

Keywords: Bendopnea, Ischemic Heart Failure, Coronary Collateral Circulation

Öz

Amaç: Koroner kollateral dolaşım (KKK), kritik koroner arter stenozu ve iskemisi sonucu gelişen fizyolojik bir koruyucu mekanizmadır. Öne eğilince nefes darlığı olan bendopne, kötü kardiyak indeks, artmış pulmoner kapiller kama basıncı ve koroner arter hastalığı ile bağlantılıdır. Bu çalışma iskemik düşük ejeksiyon fraksiyonlu kalp yetmezliği olan hastalarda KKK ve bendopne varlığı arasındaki ilişkiyi araştırmayı amaçlamaktadır.
Materyal ve Metod: Kesitsel çalışmaya Ocak 2023 ile Ocak 2024 arasında koroner anjiyografi sonrası düşük ejeksiyon fraksiyonlu kalp yetersizliği tanısı konulan 1024 hasta tarandı ve 259'u dahil etme kriterlerini karşıladı. Çalışmaya dahil edilme kriterleri stabil koroner arter hastalığı ve düşük ejeksiyon fraksiyonlu kalp yetmezliği (LVEF<%40) olması olarak tanımlandı. Hastalar bendopne+ ve bendopne- gruplarına ayrıldı. KKK değerlendirmesi için Rentrop sınıflandırması kullanıldı
Bulgular: Bendopne+ grubunda 158 hasta (ortalama yaş: 74,1±12,9 yıl, % 66.4 erkek) varken, bendopne- grubunda 101 hasta (ortalama yaş: 67,2±14,2 yıl, %70.2 erkek) vardı. Bendopne+ hastalar daha yaşlı ve daha fazla sayıda NYHA sınıf 3-4 birey vardı (p<0.001). NT-proBNP (p=0.001) ve ürik asit(p=0.001) düzeyleri bendopne+ grubunda anlamlı olarak daha yüksekti. Gensini skoru(p=0.001) ve zayıf kollateral dolaşım(p=0.001) bendopne+ grubunda anlamlı olarak daha yüksekti. Sistolik pulmoner arter basıncı (sPAP) bendopne+ grubunda belirgin olarak daha yüksekti (p=0,001). Regresyon analizleri, bendopne için bağımsız risk faktörleri olarak yaş(OR: 1.355 %95 CI:1.212-1.517 p=0.001), NT-proBNP(OR: 1.252 %95 CI:1.195-1.412 p=0.001), NYHA sınıf 3-4 (OR: 1.245 %95 CI:1.195-1.412 p=0.001), Gensini skoru(OR: 1.328 %95 CI:1.213-1.515 p=0.001), ve zayıf kollateral dolaşımı(OR: 1.318 %95 CI:1.162-1.441 p=0.001) saptadı.
Sonuç: Çalışmada, yetersiz koroner kollateral dolaşımın iskemik kalp yetmezliği hastalarında bendopne için bağımsız bir risk faktörü olduğu sonucuna varılmıştır.

Anahtar kelimeler: Bendopne, İskemik Kalp Yetmezliği, Koroner Kollateral Dolaşım

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Introduction

Coronary collateral circulation(CCC) is a physiological protective mechanism that develops as a result of critical coronary artery stenosis and ischemia. Well-developed coronary collateral circulation reduces myocardial ischemia and anginal symptoms and preserves cardiac functions (1). In stable and acute coronary artery disease (CAD) patients, it leads to a reduction in the infarct area, a decrease in the development of ventricular aneurysms, preservation of ventricular functions, and a decrease in mortality and morbidity in both the short and long term (2). Numerous studies have found a direct proportional relationship between good collateral circulation and left ventricular functions in heart failure patients (3). Additionally, studies have shown that the presence of collateral circulation has a significant impact on left ventricular reverse remodeling after percutaneous coronary intervention and coronary artery bypass graft surgery (4).

As a result of heart failure, numerous symptoms arise depending on the type and severity of the disease. Shortness of breath and its various types (orthopnea, paroxysmal nocturnal dyspnea, exercise dyspnea) are the main symptoms of acute heart failure (5). Bendopnea, also known as flexi-dyspnea, has recently been described as the development of shortness of breath within 30 seconds when leaning forward in patients with systolic and decompensated heart failure. Although its exact etiopathogenesis is not known, it is thought to occur due to increased ventricular pressure resulting from increased abdominal and intrathoracic pressure when leaning forward (6). Additionally, it has been closely associated with poor cardiac index, increased pulmonary capillary wedge pressure, right heart pressure, and pulmonary artery pressure. Studies have shown that the presence of bendopnea in patients with systolic heart failure is associated with a low quality of life and a poor prognostic indicator in the long term (7). Furthermore, it has been closely associated with many cardiovascular diseases, such as the prevalence of coronary artery disease and surgical outcomes. However, there is no study in the literature showing the relationship between coronary collateral circulation and ischemic low ejection fraction heart failure patients (8).

The aim of this study is to investigate the relationship between coronary collateral circulation and the presence of bendopnea in patients with ischemic low ejection fraction heart failure.

Materials and Methods

This study was designed as a cross-sectional study. After obtaining local ethics committee approval, 1024 patients diagnosed with ischemic low ejection fraction heart failure after coronary angiography between January 2023 and January 2024 were screened. Patients who underwent coronary angiography due to stable coronary artery disease were studied. Inclusion criteria for the study were defined as having stable coronary artery disease and low ejection fraction heart failure (LVEF<40%)(9). Patients who were diagnosed with stable CAD according to the criteria recommended by the European Society of Cardiology (21) and who underwent coronary angiography and were determined to have coronary stenosis of 95% or more in at least one major coronary vessel were included in the study (22). All patients included in the study had angina or angina-equivalent symptoms, and coronary angiography indications were established with positive non-invasive tests (exercise stress test, stress echocardiography, and myocardial perfusion scintigraphy). The study was conducted in accordance with the Declaration of Helsinki.

Patients under the age of 18, those receiving steroid treatment, those with chronic kidney or liver failure, those with systemic inflammatory disease, those with a decompensation condition, those with acute coronary syndrome, those with severe valvular disease, those who have had coronary artery bypass surgery, those who have previously undergone percutaneous coronary intervention for any reason and patients with abnormal serum electrolyte values were not included in the study. Any patients who could not bend forward because of any muscular or joint diseases or any other problems were excluded. At the end of the exclusion criteria, 259 patients were included in the study. (Figure 1: The study flowchart).

To assess the presence of bendopnea, patients were asked if they experienced shortness of breath while bending forward in a sitting position. If patients developed headache, dizziness, or syncope, they were instructed to stop bending and were given appropriate treatment. These patients were excluded from the study. The presence or absence of bendopnea and the onset time were recorded.

All patients were thoroughly evaluated for hyperlipidemia, diabetes mellitus, smoking, asthma, and Chronic Obstructive Pulmonary Disease (COPD). All medications used by the patients were thoroughly reviewed. Hematological, biochemical and serological values were obtained and recorded from peripheral blood samples taken after a 12-hour fast. Chronic kidney failure was defined as having a glomerular filtration rate of less than 60 for more than three months. For diabetes mellitus, patients taking antidiabetic medication, having fasting blood glucose levels above 126 mg/dL in at least two measurements, or an HbA1c>6.5 were considered. Hyperlipidemia was defined as having a low-density lipoprotein (LDL) level >160 mg/dL or taking statin medication. The diagnostic criterion for Chronic Obstructive Pulmonary Disease was defined as having an FEV1(Forced Expiratory Volume)/FVC (Forced Vital Capacity)< 70% or FEV1< 70% after inhaled bronchodilator administration.

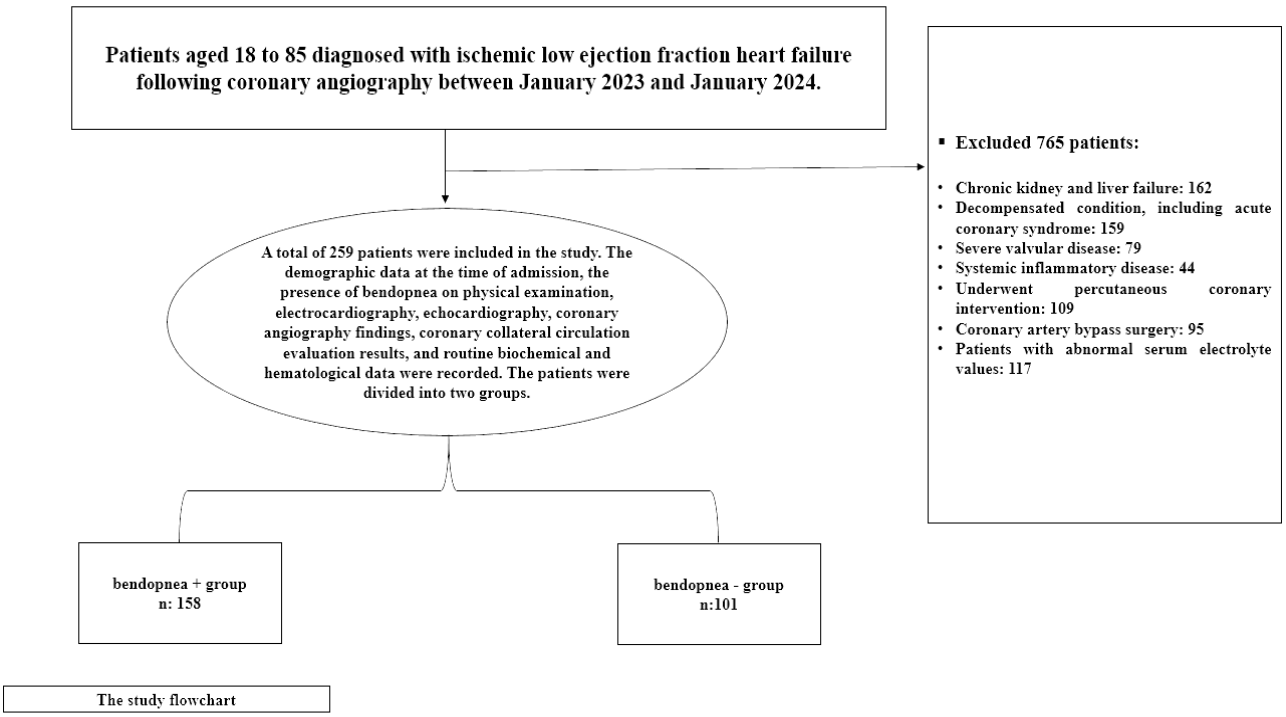

Figure 1. The study flowchart

Evaluation of Laboratory Findings

Complete blood count, renal function tests, lipid parameters, serum glucose, uric acid, blood urea nitrogen (BUN), high-sensitivity C-reactive protein (CRP) levels were recorded, and glomerular filtration rate and creatinine clearance (CrCl) were calculated.

Echocardiographic Evaluation

The echocardiographic examination of all patients included in the study was performed using an iE33 cardiac ultrasound system (Philips Healthcare) and a 2.5 to 5 MHz probe system. Ejection fraction was measured using the modified Simpson method. HFrEF occurs when the left ventricular ejection fraction (LVEF) is 40% or less(9).

Evaluation of Coronary Angiography

Coronary angiography was performed using the Allura Xper FD 10 (Philips Healthcare). Angiography was performed by puncture of the femoral artery with 6F Judkins standard right and left catheters. Iodixanol was used as the radiological contrast agent. At least four projections for the left coronary system and at least two projections for the right coronary system were recorded in digital and analog formats. Two independent cardiologists examined the coronary angiography results without knowing patient characteristics. The culprit vessel (stenosis of ≥95%) areas were divided and recorded according to three groups: right coronary artery, left descending artery, and circumflex coronary artery. Rentrop classification was used as a basis for the evaluation of CCC. Rentrop grade 0 is accepted as the absence of collateral flow, grade 1 is defined as the presence of side branches without an occluded main coronary artery, grade 2 is defined as partial visibility of an occluded main coronary artery and grade 3 is defined as complete visibility of an occluded main coronary artery. Consistent with previous studies, Rentrop grades 0 and 1 were accepted as poor collateral flow, whereas Rentrop grades 2 and 3 were accepted as good collateral flow(10).

Evaluation of CAD Severity

Gensini scoring was used to grade the extent and severity of atherosclerosis in the coronary arteries for all patients. According to the degree of angiographic stenosis, 1 point was given for 1% to 25% stenosis, 2 points for 26% to 50% stenosis, 4 points for 51% to 75% stenosis, 8 points for 76% to 90% stenosis, 16 points for 91% to 99% stenosis, and 32 points for 100% total occlusions. The Gensini score was calculated by multiplying these scores by the coefficient defined for each segment of the coronary arteries and summing the results. The segments and their coefficients were as follows: 5 for the left main coronary artery, 2.5 for the proximal segment of the left coronary artery, 1.5 for the mid segment, 1 for the apical segment, 1 for diagonal 1, and 0.5 for diagonal 2; 2.5 for the proximal segment of the circumflex coronary artery, 1 for the distal
segment, 1 for the obtuse marginal, 1 for the posterior descending artery if left dominant, 0.5 for the posterolateral artery, and 1 for the right coronary artery (proximal, mid, and distal segments), as well as the posterior descending artery (9).

Statistical Analysis

SPSS Statistics for Windows (version 25.0; IBM) and Amos (version 24.0; IBM) statistical packages were used to analyze the data. Descriptive statistics (mean [SD], median [IQR], No. [%]) for categorical and continuous variables were reported. Homogeneity of variances, one of the assumptions of parametric tests, was tested using the Levene test. The normality assumption was tested using the Shapiro–Wilk test. To assess differences between the two groups, the independent t-test was used when the assumptions of the parametric tests were met, whereas the Mann-Whitney U test was used when they were not. A p-value of < .05 was considered statistically significant. Univariate analysis was used to calculate the association of different variables with CCC. Variables for which the unadjusted p-value in the logistic regression model was < .05 were identified as potential risk markers and included in the full multivariate model.

Results

A total of 259 patients were included in this study. Patients were divided into two groups: bendopnea+ and bendopnea-. There were 158 patients (mean age: 74.1±12.9 years, % 66.4 male) in the bendopnea+ group, while there were 101 patients (mean age: years: 67.2±14.2, %70.2 male) in the bendopnea- group. No gender difference was observed between the groups, but the bendopnea+ group was statistically older(p=0.001). In terms of symptoms, the number of New York Heart Association (NYHA) class 3-4 patients was statistically higher in the bendopnea+ group(p=0.001). No differences were found between the groups when comparing patients' medical histories and treatments. The basic characteristics of the patients are shown in Table 1.

When the laboratory values of the patients were examined, no differences were observed between the groups in terms of hemoglobin, white blood cells, and renal function values. The N-terminal pro brain natriuretic peptide (NT-proBNP) (p=0.001) and Uric Acid levels (p=0.001) was statistically higher in the bendopnea+ group (Table 2).

No differences were found when comparing echocardiographic features. When comparing angiographic features, the Gensini score and poor collateral circulation were statistically higher in the bendopnea+ group (p=0.001). Additionally, in the bendopnea+ group, Systolic Pulmonary Artery Pressure (sPAP) was statistically significantly higher compared to the bendopnea- group (p= 0.001) (Table 3).

In univariate and multivariate regression analyses, age(OR: 1.355 %95 CI:1.212-1.517 p=0.001), NT-proBNP(OR: 1.252 %95 CI:1.195-1.412 p=0.001), NYHA class 3-4(OR: 1.245 %95 CI:1.195-1.412 p=0.001),, Gensini score(OR: 1.328 %95 CI:1.213-1.515 p=0.001),, and poor collateral circulation(OR: 1.318 %95 CI:1.162-1.441 p=0.001) were observed as independent risk factors for bendopnea (Table 4).

Table 1. The basic characteristics

	Bendopnea+ N:158	**Bendopnea-** N:101	**P**
Demographic and Risk Factors			
Age, years, n(%)	74.1±12.9	67.2±14.2	<0.001
Male, n(%)	105(66.4)	71(%70.2)	0.121
Smoking status, n (%)	43 (27.2)	35(34.6)	0.627
COPB, n (%)	32(20.2)	22(21.7)	0.123
Diabetus Mellitus, n (%)	91(57.5)	64(63.7)	0.341
Hypertension, n (%)	78(49.3)	54(53.4)	0.681
Hyperlipidemia, n (%)	52(32.9)	30(%29.7)	0.607
Medical Treatments			
ACEI (n, %)	71(44.9)	48(47.5)	0.232
ARB (n, %)	16(1)	11(1)	0.345
Beta blokers (n, %)	32(2)	23(2)	0.226
Statins (n, %)	30(1.8)	24(2.3)	0.426
Acetylsalicylic acid (n, %)	12 (0.7)	9(0.8)	0.369
Oral antidiabetic drugs (n, %)	72 (45)	52(51)	0.638
Insulin (n, %)	42 (26)	34(33)	0.494
NYHA class 3-4	76 (48.1)	44(43.5)	0.001

COPB: *Chronic Obstructive Pulmonary Disease,* ***ACEI:*** *Angiotensin-Converting Enzyme İnhibitors,* ***ARB :*** *Angiotensin Receptor Blockers,* ***NYHA:*** *New York Heart Association*

Table 2. Comparison of laboratory parameters

	Benopnea+ N:158	**Bendopnea-** N:101	**P value**
Laboratory measurements			
Hb (mg/dl)	13.2±1.15	12.5±2.18	0.256
Glucose (mg/dl)	160.6±51.6	154.9±55.8	0.589
WBC (x10^9)	10.1±3.12	11.1±2.11	0.321
Lymphocyte Count (x10^9)	2.3±1.1	2.8±1.4	0.254
Cr (mg/dL)	1.1±0.28	0.96±0.23	0.412
Na (mmol/L)	138.6±7.2	140.1±5.51	0.541
K (mmol/L)	4.61±1.35	4.27±1.1	0.789
Üric Acid	7.12±1.1	5.73±2.4	0.001
Total Protein (g/dL)	6.51±1.51	6.61±1.38	0.168
Calcium (mg/dL)	9.72±1.9	9.51±1.71	0.207
CRP(mg/L)	2.18 ±0.66	2.33±1.12	0.124
NT-proBNP (ng/l)	1450± 752	1059±851	0.001
HDL-C (mg/dL)	151±42.2	142±40.8	0.888
LDL-C (mg/dL)	47±12.8	46±11.5	0.133
Total Cholesterol (mg/dL)	189.5±55.8	178±51.2	0.432

***Hb**: Hemoglobin, **WBC**: White blood cells, **Cr**: Creatinine, **Na**: Sodium, **K**: Potassium, **CRP**: C-reactive protein, **NT-proBNP :** N-terminal pro brain natriuretic peptide, **HDL-C**: High-density lipoprotein cholesterol, **LDL-C**: Low-density lipoprotein cholesterol, **LVEF**: Left ventricular ejection fraction*

Table 3. Comparison of echocardiographic, electrocardiographic, and angiographic features

	Bendopnea+ N:158	**Bendopnea-** N:101	**P volue**
Echocardiographic features			
LA diameter (mm)	35 ± 5.8	34±6.6	0.741
LV diastolic diameter (mm)	59±7	58±9	0.789
LV sistolik diameter (mm)	47±11	46±10	0.124
RV Dilatation(%)	34(%21)	35(%34.6)	0.258
sPAP (mmHg)	48±14	41±12	0.001
LVEF(%)	38±4.5	36±5.1	0.251
Electrocardiographic features			
Heart Rate (/min)	81±17	82±17	0.541
QRS Duration (ms)	120±31	121±32	0.894
Angiographic Features			
Gensini score	80±5.9	91±8.1	0.001
Poor collateral circulation (Rentrop class 0-1)(%)	40±6.9	25±7.5	0.001
Culprit vessel			0.098
LAD	41(%40.5)	69(%43.6)	
LCX	28(%27.7)	43(%26.0)	
RCA	32(%31.8)	49(%30.4)	

***LA**: Left Atrium, **LV**: Left Ventricle, **RV**: Right Ventricle, s**PAP**: Systolic Pulmonary Artery Pressure, **LVEF**: Left Ventricular Ejection Fraction, **LAD**: Left Anterior Descending Artery, **LCX**: Left Circumflex Artery, **RCA**: Right Coronary Artery*

Table 4. The effects of different variables on bendopnea in univariate and multivariate logistic regression analyses

	OR	95% CI	p	OR	%95 CI	P volue
Age	1,231	1.109-1.412	0.001	1.355	1.212-1.517	0.001
NYHA class 3-4	1.356	1.224-1.514	0.001	1.245	1.195-1.412	0.001
NT-proBNP	1.257	1.112-1.377	0.001	1.252	1.185-1.322	0.001
Gensini score	1.215	1.102-1.312	0.001	1.328	1.213-1.515	0.001
Poor collateral circulation	1.211	1.101-1.310	0.001	1.318	1.162-1.441	0.001
Uric acid	1.235	0.941-1.311	0.411			
sPAB	1.314	0.944-1.432	0.259			
Diabetus Mellitus	1.187	0.954-1.352	0.654			
Gender	1.254	0.923-1.411	0.451			
Hypertension	1.121	0.898-1.332	0.369			

OR: *Odds Ratio,* ***CI:*** *Confidence Interval,* ***NYHA:*** *New York Heart Association,* ***NT-proBNP :*** *N-terminal pro brain natriuretic peptide,* ***sPAB :*** *systolic pulmonary artery pressure*

Discussion

This study is the first to investigate the relationship between coronary collateral circulation and bendopnea in patients with ischemic low ejection fraction heart failure. At the end of the study, poor collateral circulation was shown to be an independent risk factor for the presence of bendopnea.

In addition, our study demonstrated that advanced age, high NT proBNP, decreased functional capacity, and extensive coronary artery disease are independent risk factors for the development of bendopnea. With advanced age, there is an increase in comorbidities, the prevalence of coronary artery disease, increased left ventricular end-systolic pressure, decreased functional capacity, and increased pulmonary artery pressure. In the study by Kaya H. et al., aging was observed as an independent risk factor for bendopnea (11). NT-proBNP is released as a result of increased cardiac filling pressure and is directly proportional to ventricular pressure. Studies on advanced-stage heart failure have shown a close relationship between high NT-proBNP levels and bendopnea. Decreased functional capacity is closely related to increased left ventricular filling pressure and decreased cardiac index and studies on bendopnea have observed that decreased functional capacity is an independent risk factor for bendopnea. The only study investigating the relationship between the prevalence of coronary artery disease and bendopnea was conducted by Şaylık F. et al. In this study, the prevalence of coronary artery disease was observed as an independent risk factor for bendopnea (OR: 3.82), and mortality was found to be 2.21 times higher (12). In the study conducted by Rodriguez et al., the presence of bendopnea in patients with severe aortic stenosis was found to be an independent risk factor for postoperative mechanical ventilator need and prolonged hospital stays (13).

The presence of coronary collateral circulation not only reduces myocardial damage but also decreases mortality and the incidence of low cardiac output syndrome. Meier et al. demonstrated that the presence of collaterals reduces mortality by 35% (14). The positive effect of collateral circulation on left ventricular functions in coronary artery diseases has been shown in many studies. In a study conducted by Hirai et al., it was observed that left ventricular functions improved in the chronic period in the patient group with adequate collateral circulation, despite thrombolytic administration without reperfusion, while no change was observed in the patient group without adequate collateral circulation (15). Additionally, Habib et al. observed better left ventricular functions in patients with good collateral circulation in coronary artery disease patients (16). In a study conducted by Meier, Stefoana et al., an increase in left ventricular pressures was observed in the patient group without sufficient coronary collaterals during the iatrogenic 60-second occlusion of the coronary arteries in a study group of 50 patients with no difference in left ventricular ejection fraction (17).

Shortness of breath is the most important symptom in heart failure patients. Previously, exercise dyspnea, orthopnea and paroxysmal nocturnal dyspnea (PND) were defined. Bendopnea, a recently defined symptom in heart failure patients, is considered shortness of breath within 30 seconds of bending forward in patients with advanced-stage heart failure. Although its etiopathogenesis is not fully known, it is thought to be related to increased intra-abdominal and intra-aortic pressure upon bending forward. Bendopnea was introduced into the clinical literature in 2014 by Thibodeau et al. It was observed in 29 out of 102 patients (28%). Cardiac catheterization studies showed increased left ventricular filling pressure, pulmonary capillary wedge pressure and right atrial pressure in the presence of bendopnea. While all patients showed an increase in pulmonary capillary wedge pressure and right atrial pressure upon bending, there was no change in car-

diac index in patients without bendopnea, whereas a statistically significant decrease was observed in patients with bendopnea. Additionally, it was observed three times more frequently in patients with high pulmonary capillary wedge pressure and low cardiac index. However, no association was found between bendopnea and patients with high pulmonary capillary wedge pressure and normal cardiac index (18). Trinidad et al. found that the presence of bendopnea was closely related to increased PND, orthopnea, and jugular venous pressure (JVP), and particularly noted that short-term mortality was 2.3 times higher in patients with advanced-stage heart failure (19). In a meta-analysis of six studies on heart failure, Pranata B. et al. observed that orthopnea was 3.02 times, PND 2.76 times, abdominal fullness 7.5 times, and advanced-stage heart failure 7.5 times more common in the presence of bendopnea, with short- and long-term mortality being 2.21 times higher (20). In our study, the presence of insufficient coronary collateral circulation was observed as an independent risk factor for bendopnea in patients with ischemic heart failure.

Limitations

The study had some limitations. Firstly, it was a single-center, cross-sectional study. The research was conducted with a relatively small patient group. Due to data loss, many patients were excluded from the study.

The results of the study need to be supported by randomized controlled trials.

Conclusion

In our study, the presence of insufficient coronary collateral circulation was observed as an independent risk factor for bendopnea in patients with ischemic heart failure.

Ethical Approval: *Ethical approval was obtained from the İzmir Bakırçay University Non-Invasive Clinical Research Ethics Committee with the application number 2065 (date: 26/02/2025).*

Author Contributions:
Concept: İ.K, F.S.
Literature Review: İ.K, F.S.
Design : İ.K, F.S.
Data acquisition: İ.K, F.S.
Analysis and interpretation: İ.K, F.S.
Writing manuscript: İ.K, F.S.
Critical revision of manuscript: İ.K, F.S.

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