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Short Communication

A novel diastolic dysfunction score: A proposed diagnostic predictor for left ventricular dysfunction in obese population

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Abstract

Obesity-related diastolic dysfunction is an emerging contributor to heart failure and cardiovascular mortality. However, effective and accessible diagnostic tools are still limited. Current methods for assessing diastolic dysfunction are often invasive or technologically demanding, making them impractical for routine clinical use and community settings. The aim of this study was to develop a novel, non-invasive scoring system designed to predict diastolic dysfunction in obese adults, addressing this diagnostic gap. This community-based, prospective cross-sectional study was conducted in Jakarta, Indonesia, from March to November 2021, and included 82 participants aged 18 to 60 years, all with a body mass index (BMI) ≥25 kg/m². Patients with acute or critical illnesses, valvular heart diseases, or acute confusional states were excluded. Each participant underwent blood tests, polysomnography, and echocardiography. Of the study population, 80.5% were diagnosed with obstructive sleep apnea (OSA), and 12.2% exhibited diastolic dysfunction, all within the OSA group. The novel scoring system integrates four predictors: oxygen desaturation index (ODI) ≥39 (score 1; prevalence ratio: 4.31 (95% confidence interval (CI): 1.58–11.75)), HbA1C ≥5.95% (score 2; prevalence ratio: 6.32 (95%CI: 2.84–14.06)), pulmonary artery wedge pressure (PAWP) ≥10 mmHg (score 1; prevalence ratio: 5.95 (95%CI: 2.30–15.39)), and global longitudinal strain (GLS) ≥-16.95% (score 1; prevalence ratio: 4.32 (95%CI: 1.87–9.99)). A score of ≥2 predicted diastolic dysfunction with 90% sensitivity, with positive predictive value and negative predictive value of 40.91% and 98.33%, respectively. In conclusion, the diastolic dysfunction score is a simple and practical tool for the early detection of diastolic dysfunction in obese individuals without cardiovascular symptoms.

Keywords: Global longitudinal strain, HbA1C, obesity, oxygen desaturation index, pulmonary artery wedge pressure

Introduction

Obesity prevalence is rising worldwide, with approximately 600 million adults affected [1]. The Global Burden of Disease (GBD) Obesity Collaborators reported that in 73 countries, the number

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of obese adults doubled between 1980 and 2015, a trend that continues to escalate annually [1]. Obesity significantly contributes to mortality, with over 2.8 million obesity-related deaths each year [2]. Defined as a body mass index (BMI) ≥25 kg/m² in the Asia-Pacific region, obesity is linked to multiple comorbidities, including diabetes mellitus, hypertension, dyslipidemia, stroke, sleep-disordered breathing (SDB), and cardiovascular conditions such as heart failure (HF) [3]. Cardiovascular diseases account for two-thirds of the 4 million deaths attributed to high BMI annually, even after adjusting for other factors such as smoking [1,4].

Diastolic dysfunction, a precursor to HF, is characterized by the inability of the ventricle to relax fully, often due to increased left ventricular end-diastolic pressure (LVEDP). It can lead to ventricular stiffness and hypertrophy, particularly in obese individuals. Echocardiographic parameters, such as E/A ratio, E/e' ratio, and deceleration time (DT), are commonly used to evaluate diastolic function [5-7]. Previous studies have linked diastolic dysfunction to obesity-related conditions such as diabetes mellitus [8,9] and SDB [10,11]. Early detection of obesity-related cardiac complications remains challenging due to limitations in current diagnostic tools. Currently, available methods are often underutilized in broader settings, especially in areas lacking access to advanced diagnostic technologies.

Among the subtypes of SDB, obstructive sleep apnea (OSA) is the most prevalent [8]. Characterized by repeated apnea and hypopnea episodes during sleep, OSA often leads to transient hypoxemia, hypercapnia, and involuntary awakenings [9]. The apnea-hypopnea index (AHI), measured by polysomnography, is the standard for classifying OSA severity. The oxygen desaturation index (ODI), a simpler metric derived from nocturnal oximetry, is strongly correlated with AHI and can identify undiagnosed SDB cases [10,11]. In obese patients, OSA exacerbates diastolic dysfunction through mechanisms such as intermittent hypoxia and increased cardiac workload. In addition to OSA, diabetes mellitus contributes to diastolic dysfunction through structural and functional changes in the myocardium. Hemoglobin A1C (HbA1C), a marker of average plasma glucose levels over two to three months, is frequently used to assess glycemic control and diagnose diabetes [12]. Elevated HbA1C levels are associated with diabetic cardiomyopathy, which involves myocardial fibrosis, stiffness, and impaired ventricular relaxation [13].

While obesity is often associated with comorbidities such as hypertension and dyslipidemia, these conditions were not included in the scoring model developed in the present study for several reasons. Hypertension, while prevalent in obese individuals, is an indirect contributor to diastolic dysfunction, often serving as a consequence rather than a direct cause of cardiac remodeling [5,6]. Likewise, dyslipidemia, though commonly observed in obese patients, does not directly correlate with the specific mechanisms of diastolic dysfunction in the same way as other factors such as ODI, HbA1C, pulmonary artery wedge pressure (PAWP), and global longitudinal strain (GLS) [7,14]. These latter parameters were chosen because they directly reflect the pathophysiological processes underlying diastolic dysfunction in obesity, including myocardial strain, fibrosis, and impaired ventricular relaxation, offering a more targeted approach for early detection [13,15]. By focusing on these parameters, the aim of this study was to develop a scoring system that is both clinically practical and directly relevant to the early stages of diastolic dysfunction in obese individuals.

Left ventricular (LV) filling properties are often evaluated using PAWP, an echocardiographic parameter that serves as a surrogate for LVEDP and avoids invasive catheterization. PAWP is valuable in assessing diastolic dysfunction and identifying elevated LV filling pressures [16,17]. GLS, another echocardiographic parameter, evaluates myocardial deformation and is sensitive to early myocardial changes. GLS abnormalities in obesity-related diastolic dysfunction are linked to fibrosis of sub-endocardial longitudinal fibers [18,19]

This study focuses on developing a novel, non-invasive scoring system to predict diastolic dysfunction in obese individuals without overt cardiovascular symptoms. Unlike traditional methods, the proposed score prioritizes parameters with strong independent predictive value (ODI, HbA1C, PAWP, and GLS). By integrating these factors, this scoring system aims to bridge the gap in accessible diagnostic tools and provide an effective means for early detection and intervention. The illustration of the association between ODI, HbA1C, PAWP, and GLS with diastolic dysfunction is presented in **Figure 1**. The investigation of a novel scoring system for

predicting diastolic dysfunction is critical due to the increasing burden of obesity-related heart failure and the lack of accessible diagnostic tools in routine practice. Current methods, such as invasive catheterization or complex echocardiographic algorithms, are not always feasible in community or resource-limited settings. This study offers a novelty in its focus on integrating non-invasive, practical, and widely available parameters—ODI, HbA1C, PAWP, and GLS—to create a scoring system tailored for obese individuals. By prioritizing parameters that directly reflect diastolic dysfunction while excluding indirect comorbidities such as hypertension, this approach simplifies assessment without compromising accuracy. To the best of our knowledge, this is the first study in Indonesia to propose such a model, addressing a significant gap in the early detection of diastolic dysfunction and enabling timely preventive measures to reduce its progression to heart failure.

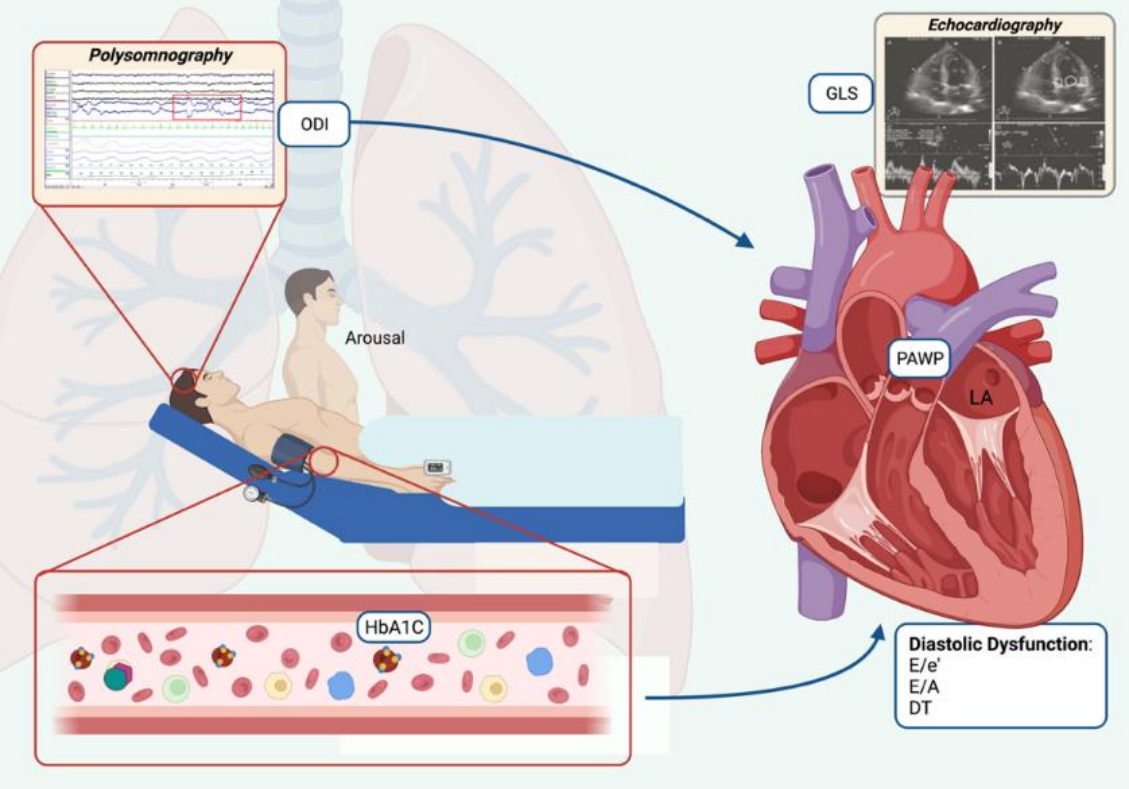

Figure 1. Schematic diagram illustrating the association between key non-invasive parameters and diastolic dysfunction, as captured through echocardiographic measurements. The oxygen desaturation index (ODI) and arousal events, derived from polysomnography, reflect the impact of sleep-disordered breathing, particularly obstructive sleep apnea (OSA), on cardiac function through intermittent hypoxia and increased cardiac workload. Hemoglobin A1C (HbA1C) serves as a marker of long-term glycemic control, with elevated levels linked to diabetic cardiomyopathy, myocardial fibrosis, and impaired ventricular relaxation. Pulmonary artery wedge pressure (PAWP), an echocardiographic surrogate for left ventricular end-diastolic pressure (LVEDP), indicates elevated left atrial pressure, while global longitudinal strain (GLS) assesses myocardial deformation and detects early subclinical changes in ventricular function. These parameters correlate with echocardiographic markers of diastolic dysfunction, including E/e' ratio, E/A ratio, and deceleration time (DT), providing a non-invasive, practical approach for early detection of diastolic dysfunction in obese individuals without overt cardiovascular symptoms.

Methods

Study design and subject

This community-based, cross-sectional study was conducted in Jakarta, Indonesia, from March to November 2021. Participants aged 18 to 60 years with a BMI ≥25 kg/m² were consecutively recruited from local health screening programs and community health centers to ensure the inclusion of obese individuals without cardiovascular symptoms. Patients with acute and/or

critical illnesses, valvular heart diseases, or acute confusional states were excluded. Since the study was conducted during the pandemic, eligible patients were subjected to coronavirus disease 2019 (COVID-19) screening using a symptom screening questionnaire, antigen swab test, and chest X-ray. Those with positive COVID-19 test results were excluded from the study.

The minimum required sample size was calculated using a single proportion formula with a 95% confidence interval (CI), 5% margin of error, and estimated 10% prevalence of diastolic dysfunction in obese individuals, yielding a minimum of 138 participants. However, due to recruitment challenges during the COVID-19 pandemic, 90 participants were enrolled, with 82 completing the study.

Data sampling

Participants completed validated tools for assessing the risk and symptoms of OSA, including STOP-Bang and Berlin questionnaires, which evaluate age, sex, BMI, neck circumference, blood pressure, snoring during sleep, fatigue, and apnea. Additionally, participants underwent a physical examination. BMI measurements were used to classify participants into obesity groups. Polysomnography tests using SOMNOMEDIC type 2 were conducted to confirm OSA diagnoses with ODI calculated as the number of desaturation episodes (≥4% drop in saturation for at least 10 seconds) per hour of sleep [10]. Peripheral blood tests were conducted to measure HbA1C levels.

Echocardiographic assessment

Two blinded expert cardiologists performed two-dimensional (2D) transthoracic echocardiograms using the Philips EPIQ Elite e95 (Philips Ultrasound, Bothell, WA, USA). The evaluations included PAWP, GLS, and diastolic dysfunction, following the 2016 American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI) guidelines [6,20].

PAWP was estimated using a validated echocardiographic formula ($PAWP=18.525\times V_A^{\,2}$), where V_A represents the late diastolic blood influx rate during atrial contraction. The normal value of PAWP typically ranges from 6 to 12 mmHg at rest. Values above this range suggest elevated left atrial pressure, which can indicate conditions such as left ventricular dysfunction, heart failure, or volume overload. Elevated PAWP (>15 mmHg) indicates increased LV filling pressures, often due to left-sided heart failure or diastolic dysfunction [6].

GLS was measured using 2D speckle-tracking echocardiography in apical four-chamber, two-chamber, and long-axis views. The maximum achievable frame rate was used to optimize speckle tracking analysis, ensuring accuracy in assessing LV myocardial deformation [20]. Diastolic dysfunction was defined per ASE/EACVI guidelines to emphasize the identification of elevated LVEDP and the differentiation of diastolic dysfunction grades, focusing on mitral peak velocity of early filling (E) to early diastolic mitral annular velocity (e') (E/e'), the ratio of early (E) to late (A) ventricular filling velocities (E/A), and DT. Given the asymptomatic study population, the predictive capability of diastolic dysfunction was prioritized over differentiation between severity grades.

Analytical approach

PAWP and GLS were treated as predictors in statistical analyses but were not used to define diastolic dysfunction if established clinical criteria were not included. In this study, PAWP was calculated using Doppler echocardiography parameters, including mitral inflow velocities (E, A), E' velocities from tissue Doppler imaging, and the E/E' ratio. Circular reasoning was avoided by ensuring that variables used to diagnose diastolic dysfunction were not included in its predictive model.

Statistical analysis

The association between independent variables and diastolic dysfunction was assessed using appropriate statistical methods. Data distribution was evaluated, with non-parametric tests applied when necessary. The Mann-Whitney test was used to compare continuous variables between groups with and without diastolic dysfunction. Receiver operating characteristic (ROC) curve analysis was performed to identify the optimal cutoff values for each significant continuous

variable, maximizing sensitivity and specificity. These ROC-derived cutoff values were then used to categorize continuous variables for subsequent bivariate and multivariate analyses. This categorization aimed to simplify clinical interpretation while maintaining statistical rigor, as these thresholds were clinically relevant.

Bivariate analysis estimated prevalence ratios (PR) and multivariate Poisson regression adjusted for potential confounders (significance level set at $p<0.05$). Model performance was assessed using the Hosmer-Lemeshow test and the area under the ROC curve (AUC). IBM SPSS statistics version 26 (IBM, New York, USA) and STATA/SE version 14.2 were used for all statistical analyses.

Results

Patients' characteristics

This research involved 90 obese patients who met the eligibility criteria. Three participants were lost during the follow-up period, and five did not pass the echocardiographic examination. A total of 82 participants met the requirements and completed all stages of the study. The median age was 49, with an interquartile range of 11. Of the total patients, 48 (58.5%) were male. Most patients (80.5%) received a diagnosis of OSA. Among the 82 patients, 10 (12.2%) showed diastolic dysfunction, all from the OSA group. The details of the participants' characteristics are presented in **Table 1**. Significant differences were observed in several variables between subjects with and without diastolic dysfunction, including ODI ($p=0.017$), HbA1C ($p=0.022$), PAWP ($p=0.014$), and GLS ($p=0.038$).

Table 1. Comparative analysis of subjects with and without diastolic dysfunction

Variable	Median (interquartile range)		*p*-value
	Without diastolic dysfunction	With diastolic dysfunction	
	n=72	n=10	
Age, median (IQR) (year)	48 (11.75)	49.5 (11.75)	0.534
Sex, n (male/female)	42/30	6/4	0.854
Body mass index (BMI), mean±SD (kg/m²)	32.89±5.08	31.95±4.19	0.621
Oxygen desaturation index (ODI)	18.50 (27.75)*	41 (30.50)*	0.017*
HbA1C	5.75 (0.80)**	6.15 (3.65)**	0.022**
Pulmonary artery wedge pressure (PAWP)	11.12 (2.68)*	14.59 (5.98)*	0.014*
Global longitudinal strain (GLS)	-17.90 (3.05)*	-16.40 (3.10)*	0.038*

*Statistically significant at $p<0.05$
**Statistically significant at $p<0.025$

ROC analysis and threshold values

ROC analysis identified optimal cutoff values for ODI, HbA1C, PAWP, and GLS, which were used to categorize these continuous variables into discrete variables for further statistical analysis (**Table 2**).

Table 2. Characteristic of ROC curve in predicting the diagnosis of diastolic dysfunction and determining a cutoff value for optimal sensitivity and specificity

Variable	AROC (95%CI)	Cutoff	Sens (%)	Spec (%)	PPV (%)	NPV (%)
ODI	0.69 (0.55 to 0.84)	≥39	70	76.4	29.17	94.83
HbA1C (%)	0.64 (0.43 to 0.85)	≥5.95	60	65.3	19.35	92.16
PAWP (mmHg)	0.77 (0.58 to 0.95)	≥10.84	80	61.1	17.78	94.59
GLS (%)	0.74 (0.58 to 0.90)	≥-16.95	70	70.8	25	94.44

AROC: area under receiving operating characteristic curve; CI: confident interval; GLS: global longitudinal strain; NPV: negative predictive value; ODI: oxygen desaturation index; PAWP: pulmonary artery wedge pressure; PPV: positive predictive value; Sens: sensitivity; Spec: specificity

Bivariate and multivariate analysis

Bivariate analysis identified ODI ($p=0.008$), HbA1C ($p=0.001$), PAWP ($p<0.001$), and GLS ($p=0.021$) as significant predictors of diastolic dysfunction. The results of Poisson regression models indicated that these variables, when categorized according to the ROC-derived thresholds, were independent predictors of diastolic dysfunction (**Table 3**). Following the

bivariate analysis, all significant variables were analyzed using the Poisson regression test in a multivariate analysis. ODI ≥39 (p=0.004), HbA1C ≥5.95% (p<0.001), PAWP ≥10.84 mmHg (p<0.001), and GLS ≥-16.95 (p=0.001) were identified as independent indicators for diagnosing diastolic dysfunction (**Table 3**).

Table 3. Final Poisson regression model to predict diastolic dysfunction

Variable	Bivariate test			Adjusted multivariate test		
	PR (95%CI)	*p*-value	Coeff	PR (95%CI)	*p*-value	Coeff
ODI	5.64 (1.57–20.16)	0.008	1.00	4.31 (1.58–11.75)	0.004	1
HbA1C (%)	6.17(2.18–17.45)	0.001	1.58	6.32 (2.84–14.06)	<0.001	2
PAWP (mmHg)	9.62 (2.77–33.42)	<0.001	1.29	5.95 (2.30–15.39)	<0.001	1
GLS (%)	4.50 (1.25–16.20)	0.021	1.20	4.32 (1.87–9.99)	0.001	1

GLS: global longitudinal strain; ODI: oxygen desaturation index; PAWP: pulmonary artery wedge pressure; PR: prevalence ratio

Development of scoring system

The calculation for the diastolic dysfunction score involved dividing every coefficient from the multivariate Poisson regression by the model's smallest coefficient (ODI ≥39). The weight of the score was determined by dividing the coefficient/standard error (2.85) for elevated HbA1C ≥5.95%, PAWP ≥10.84 mmHg, and GLS ≥-16.95%, resulting in values of 1.58, 1.29, and 1.20, respectively. Rounding these values to the nearest integer, the score weight was two for the HbA1C variable and one for the other variables (**Table 3**). The probability of diastolic dysfunction score in this study is presented in **Table 4**.

Table 4. Probability of the diastolic dysfunction score

Score	Diastolic dysfunction	Normal diastolic	Probability (%)
0	0	33	0.33
1	1	26	2.57
2	2	10	17.21
3	4	3	62.09
4	3	0	92.81

Sensitivity and specificity of diastolic dysfunction score

The sensitivity and specificity of the newly developed diastolic dysfunction score at various cutoff points are presented in **Table 5**. At a cutoff of ≥2, the score exhibited an optimal balance with sensitivity of 90% and specificity of 81.94%. The positive predictive value (PPV) was 40.91% and the negative predictive value (NPV) was 98.33%. The overall accuracy of the score in predicting diastolic dysfunction was 82.93%. The AUC for the diastolic dysfunction score was 0.933 (95%CI: 0.86–1.00; p<0.001), as presented in **Figure 2**. The Hosmer-Lemeshow test for goodness of fit yielded a p-value of 0.878, indicating good model fitness. The AUC for diastolic dysfunction score was 0.933 (95%CI: 0.86–1.00; p<0.001).

Table 5. Diastolic dysfunction score sensitivity and specificity evaluation

Score	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Correctly classified (%)
≥1	100	45.83	20.41	100	52.44
≥2	90	81.94	40.91	98.33	82.93
≥3	70	95.83	70.0	95.83	92.68
≥4	30	100	100	91.46	91.46

Illustrative case from the study population

A 46-year-old male with no cardiovascular symptoms underwent a general health examination. Anthropometric measurements showed a weight of 100.2 kg, height of 168 cm, and BMI of 35.5 kg/m². His blood pressure was 180/122 mmHg, and blood tests revealed an HbA1c level of 8.4%. Polysomnography showed an ODI of 16. Echocardiography findings included a PAWP of 12.21 mmHg and GLS of -7%. Based on the newly developed scoring system, the total score was 4. The scoring details of this illustrative case are presented in **Table 6**.

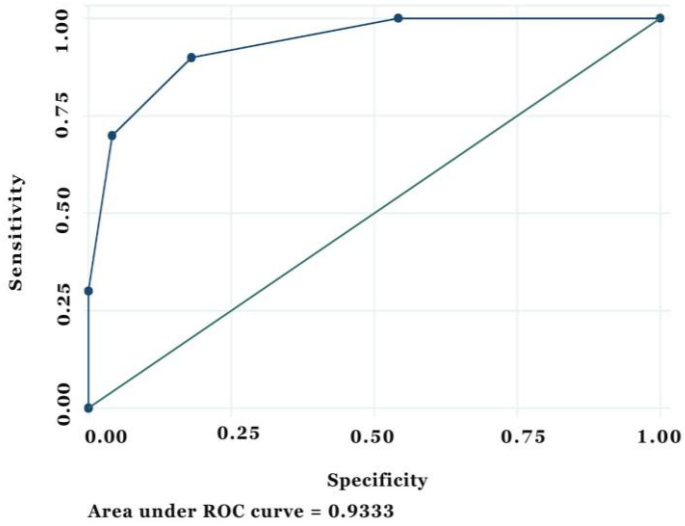

Figure 2. Area under the curve (AUC) for the diastolic dysfunction score.

Table 6. Example of novel diastolic dysfunction scoring

Variable	Yes	No	Score
Oxygen desaturation index (ODI) ≥39	0	1	0
Hemoglobin A1C (HbA1C) ≥5.95%	2	0	2
Pulmonary artery wedge pressure (PAWP) ≥10.84 mmHg	1	0	1
Global longitudinal strain (GLS) ≥-16.95%	1	0	1
Total score	4	0	4

Discussion

This is an initial study in Indonesia to develop a scoring method for predicting diastolic dysfunction in obese individuals without cardiovascular symptoms. Early detection of diastolic dysfunction is crucial for reducing mortality and improving outcomes. Echocardiography is a non-invasive tool that assesses diastolic function, but cardiac catheterization remains the gold standard [6,7,21]. By adding new parameters (ODI, HbA1C, PAWP, and GLS), this study aimed to identify independent predictors and develop a practical scoring system for clinical use. To address concerns about circular reasoning, PAWP and GLS were treated solely as predictors in the regression models, with thresholds determined independently through ROC.

The illustration of the PAWP assessment using echocardiography for non-invasive estimation is presented in **Figure 3**. PAWP, a surrogate for left atrial pressure, was calculated on a 55-year-old female using the validated formula. This value indicates elevated left atrial pressure, consistent with diastolic dysfunction. Despite a preserved left ventricular ejection fraction (LVEF=75%), the reduced E/A ratio (0.65) highlights impaired ventricular relaxation, characteristic of grade I diastolic dysfunction. The patient's morbid obesity and OSA contribute to elevated left ventricular filling pressures by increasing afterload and impairing myocardial compliance. This non-invasive echocardiographic assessment provides a safer alternative to cardiac catheterization and serves as a valuable tool for monitoring hemodynamic status in daily clinical practice, particularly in patients with complex cardiovascular risk profiles like this case.

The findings demonstrate that obesity, OSA, and diabetes mellitus contribute significantly to diastolic dysfunction. Obesity increases metabolic demands, resulting in hyperdynamic circulation, ventricular remodeling, and a higher prevalence of left ventricular hypertrophy [22,23]. The presence of OSA further exacerbates this condition through intermittent hypoxia, oxidative stress, and increased sympathetic activation, which impair myocardial relaxation and elevate left atrial pressure. Studies have shown a strong correlation between OSA severity and diastolic dysfunction, with nocturnal hypoxia episodes leading to ventricular remodeling and reduced myocardial compliance [24-28]. OSA leads to left ventricular remodeling [29], nocturnal cardiac ischemia [33], ventricular arrhythmia [30], increased sympathetic nerve activation [31], hypercoagulation [32,36], and LV diastolic dysfunction [33].

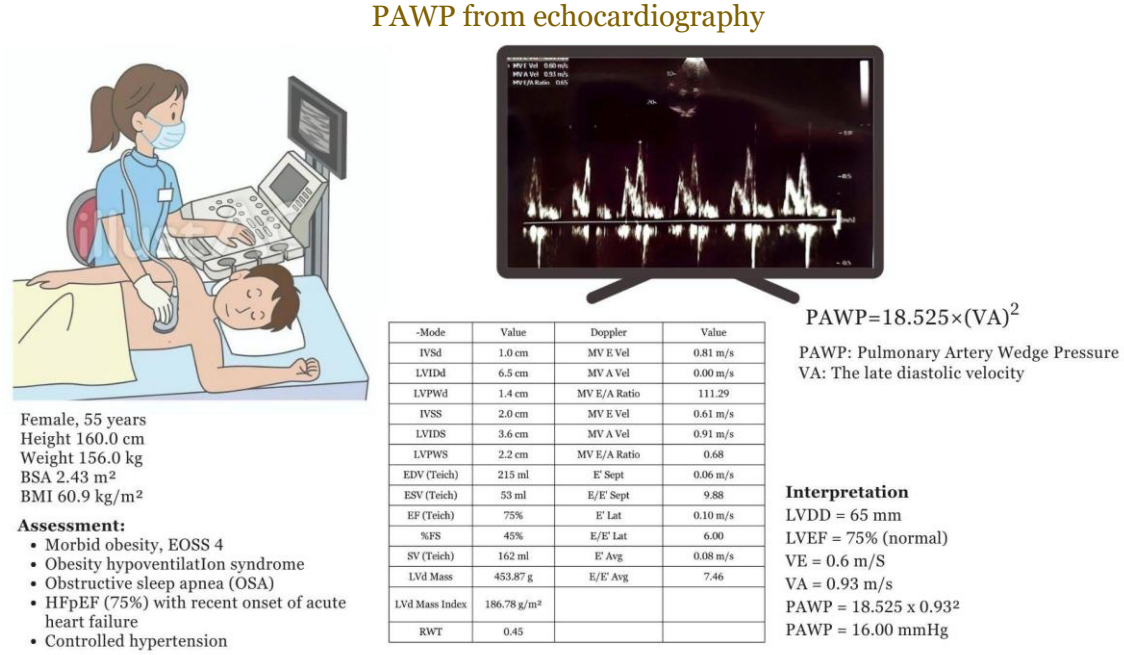

Figure 3. Pulmonary artery wedge pressure (PAWP) assessment using echocardiographic parameters in a 55-year-old morbidly obese female patient. The patient, with a BMI of 60.9 kg/m² and comorbidities including obesity hypoventilation syndrome, obstructive sleep apnea (OSA), and controlled hypertension, presented with recent onset of acute heart failure with preserved ejection fraction (HFpEF). Echocardiographic evaluation reveals a left ventricular end-diastolic diameter (LVDD) of 65 mm, suggestive of cardiomegaly, while the left ventricular ejection fraction (LVEF) remains within normal limits at 75%. Diastolic function assessment shows a peak early diastolic velocity (V_E) of 0.6 m/s and a peak atrial velocity (V_A) of 0.93 m/s. PAWP is non-invasively estimated at 16.00 mmHg using the formula PAWP=18.525 × VA^2.

The selection of parameters (ODI, HbA1C, PAWP, and GLS) was based on their significant associations with left ventricular diastolic dysfunction (LVDD) and their relevance to obesity-related cardiac abnormalities. ODI is a significant parameter that highlights the impact of OSA and is closely associated with the apnea-hypopnea index (AHI) that can predict OSA severity [10,34,35]. Likewise, diabetes mellitus has been extensively linked to adverse cardiac structural changes, with hyperglycemia-induced collagen deposition and myocardial fibrosis reducing ventricular elasticity [36-39].

A novel ODI cutoff (≥39) was identified as an independent predictor of diastolic dysfunction, consistent with previous research linking OSA severity to myocardial strain [39,40]. Similarly, HbA1C (≥5.95%) emerged as a key predictor, reinforcing its role beyond glycemic control in assessing cardiovascular risk [41,42]. PAWP and GLS provided additional insights into left ventricular filling pressures and myocardial strain, enhancing the model's predictive capability. PAWP is invaluable for assessing LVDD, particularly in asymptomatic obese individuals [17,43,44]. GLS provides a nuanced understanding of subclinical ventricular changes, making it invaluable for detecting early-stage diastolic dysfunction [45-49]. The integration of these parameters into a single scoring system offers a comprehensive and practical approach to the early identification of diastolic dysfunction, particularly in resource-limited settings where advanced diagnostic tools may not be available. Given that traditional diastolic dysfunction assessment often relies on invasive procedures or advanced imaging techniques, this model provides a simpler, more accessible alternative for risk stratification in obese individuals. Additionally, this scoring system has the potential for broader applications in screening individuals at risk for developing heart failure, particularly in primary care and community settings where routine echocardiographic assessments may not be feasible. The combination of metabolic, respiratory and echocardiographic parameters provides a multifactorial approach to identifying individuals at high risk of diastolic dysfunction before clinical symptoms manifest. Future studies should explore the feasibility of implementing this scoring model in larger

populations and in diverse healthcare settings, assessing its impact on clinical decision-making and patient outcomes.

This study has limitations, including a relatively small sample size and focus on asymptomatic individuals, which may limit generalizability. Moreover, the absence of invasive measurements restricts direct validation of LV filling pressures. While this study emphasized non-invasive prediction, further research should explore the scoring system's applicability in symptomatic populations and hospital settings. Longitudinal studies are needed to determine its utility in predicting cardiovascular outcomes and guiding clinical decision-making. Despite these limitations, this study provides a foundational framework for developing a practical, non-invasive tool for identifying diastolic dysfunction in obese individuals.

Conclusion

This study presents a novel, non-invasive scoring system for predicting diastolic dysfunction in obese individuals. The diastolic dysfunction score, derived from ODI, HbA1C, PAWP, and GLS, demonstrated strong predictive performance (90% sensitivity and 81.94% specificity). Its simplicity and accuracy make it a promising tool for early detection, particularly in resource-limited settings. However, further validation in larger populations is needed to assess its prognostic value and integration into clinical screening programs.

Ethics approval

This study has received approval from the Faculty of Medicine, Universitas Indonesia Research Ethics Committee KET-1205/UN2.F1/ETIK/PPM.00.02/2020. After being fully informed, participants provided written consent before participating in the study.

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None.

Competing interests

There are no disclosed conflicts of interest for any of the authors.

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None.

Underlying data

The supporting data for this study is available upon request from the corresponding author.

Declaration of artificial intelligence use

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

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