Journal of Clinical Ultrasound

WILEY

RESEARCH ARTICLE OPEN ACCESS

Application Value of Myocardial Segmental Thickness Variability Measured by Echocardiography in Distinguishing Ischemic and Nonischemic Dilated Cardiomyopathy

Can Xu | Dongjin Wang

Department of Cardiac Surgery, Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School, Nanjing, China

Correspondence: Dongjin Wang (wangdongjinnj@163.com)

Received: 4 September 2024 | **Accepted:** 15 November 2024

Keywords: dilated cardiomyopathy | echocardiography | ischemic cardiomyopathy | regional wall motion abnormalities | segmental thickness variability

ABSTRACT

Purpose: The aim of this study is to evaluate the clinical value of myocardial segmental thickness variability (STV) measured by echocardiography in distinguishing ischemic cardiomyopathy (ICM) from nonischemic dilated cardiomyopathy (NIDCM).

Methods: This study included 120 patients diagnosed with dilated cardiomyopathy, divided into ICM ($n = 43$) and NIDCM ($n = 77$) groups based on coronary angiography. Traditional echocardiographic parameters, STV, and regional wall motion abnormalities (RWMA) were compared. The diagnostic value of STV was assessed using receiver operating characteristic (ROC) curve analysis.

Results: There were no significant differences in traditional echocardiographic parameters between the groups. The NIDCM group had a significantly higher mean STV compared to the ICM group. An STV threshold of 0.768 provided a sensitivity of 86.0% and a specificity of 94.8% for distinguishing ICM from NIDCM. Combining STV with RWMA improved diagnostic accuracy.

Conclusion: STV measured by echocardiography is a valuable, noninvasive tool for differentiating between ICM and NIDCM, offering high sensitivity and specificity. This approach enhances diagnostic precision, supporting its use in clinical practice to guide appropriate treatment strategies.

1 | Introduction

Nonischemic dilated cardiomyopathy (NIDCM) and ischemic cardiomyopathy (ICM) present similar clinical manifestations, such as shortness of breath, chest tightness, and edema. Echocardiography can detect progressive ventricular dilation in both conditions [1]. Despite these similarities, the underlying causes of the diseases differ, leading to distinct treatment strategies. Currently, distinguishing between NIDCM and ICM primarily involves coronary angiography, which can assess coronary artery stenosis to diagnose myocardial ischemia [2]. However, this procedure is invasive. Therefore, there is a growing interest in developing noninvasive methods to differentiate between ICM and NIDCM. ICM results in motion abnormalities and varying thickness in the ventricular wall due to ischemia and necrosis of myocardial cells [3]. This study utilizes echocardiography to assess the thickness of different segments of the ventricular wall and calculate segmental thickness variability (STV) to investigate its diagnostic utility in distinguishing between ischemic and NIDCM. The results of the study are detailed below.

2 | Materials and Methods

2.1 | Study Subjects

A cohort of 120 patients diagnosed with dilated cardiomyopathy (DCM) at our hospital between January 2019 and October 2023 were included in the study. The age of the patients ranged from 34 to 75 years, with a mean age of 54.93 ± 10.83 years. The inclusion criteria were: (1) echocardiographic evidence of left ventricular dilation (left ventricular end-diastolic dimension (LVEDD), male > 5.8 cm, female > 5.2 cm), meeting the diagnostic criteria for DCM; (2) left ventricular ejection fraction (LVEF) < 40%; (3) coronary angiography to determine myocardial ischemia; (4) complete echocardiography and angiography data. Exclusion criteria were: (1) previously known history of DCM; (2) history of heart failure; (3) previous diagnosis of coronary heart disease; (4) acute coronary syndrome; (5) incomplete echocardiography or angiography data; (6) concomitant valvular heart disease; (7) poor quality echocardiographic images that prevent accurate measurement of ventricular wall thickness or motion. Patients were divided into the ICM group ($n = 43$) and the NIDCM group ($n = 77$) based on angiography results. The diagnostic criteria for ICM were: coronary angiography showing left anterior descending artery stenosis ≥ 70% or multiple coronary artery stenosis. The diagnostic criteria for NIDCM were: coronary angiography showing left anterior descending artery stenosis < 70% or single-vessel stenosis excluding the left anterior descending artery.

2.2 | Equipment and Methods

2.2.1 | Echocardiography Examination

The Philips EPIQ 7C ultrasound diagnostic system, equipped with an S5-1 convex array probe operating at a frequency range of 1.7–3.4 MHz, was utilized for echocardiographic examinations. Patients were positioned in the left lateral decubitus position and instructed to maintain quiet breathing, while an electrocardiogram (ECG) was connected. Standard echocardiographic measurements such as LVEDD, left ventricular end-diastolic volume (LVEDV), LVEF, E-point septal separation (EPSS), and stroke volume (SV) were obtained.

2.2.2 | STV

According to the 17-segment model established by the American Heart Association (AHA), the thickness of each left ventricular segment was measured at end-diastole using parasternal short-axis views at three levels: the mitral valve level (basal), papillary muscle level (mid), and apical level (apical). The STV is calculated as the ratio of the thinnest wall thickness to the thickest wall thickness; when wall thickness is uniform, STV = 1. A value of STV < 0.65 indicates significant STV. For visual reference, please refer Figures 1 and 2.

2.2.3 | Regional Wall Motion Abnormalities (RWMA)

The diagnosis of RWMA was determined according to the criteria outlined in the "Chinese Adult Echocardiography Measurement Guidelines" [4]. Reduced motion, hypokinesia, or paradoxical motion were all classified as RWMA, with the exception of isolated septal motion abnormalities attributed to right ventricular overload, left bundle branch block, or ventricular pacing.

2.2.4 | Observation Indicators

Conventional echocardiographic indicators (such as LVEDD, LVEF, LVEDV, EPSS, and SV), along with the incidence of STV and RWMA, were compared between the two groups. The diagnostic threshold value and application value of STV for ICM were calculated using angiography as the gold standard.

2.3 | Statistical Analysis

Data were analyzed using SPSS 22.0 software. Count data were presented as frequencies (rates) and compared between groups

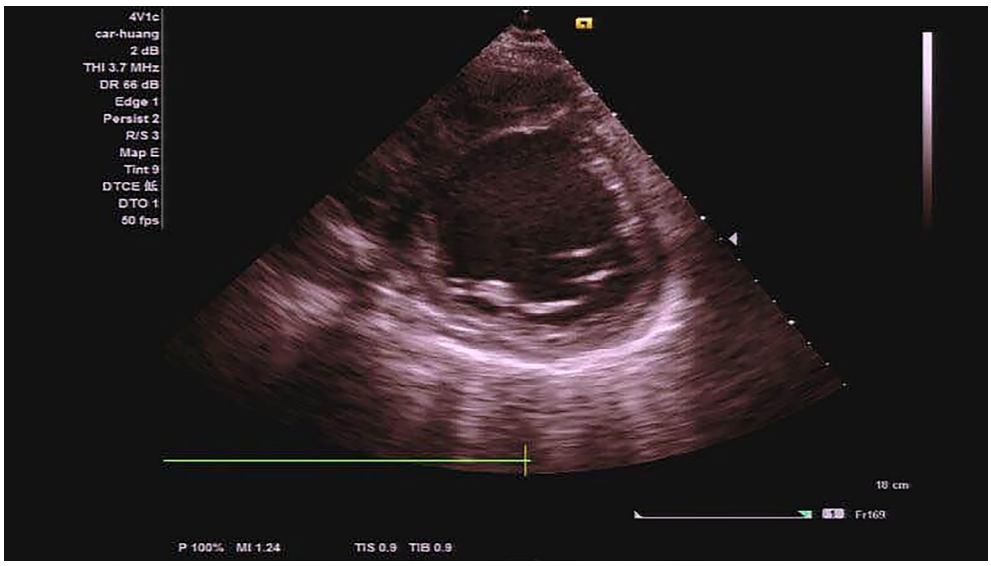

FIGURE 1 | Echocardiographic parasternal short-axis view of nonischemic dilated cardiomyopathy.

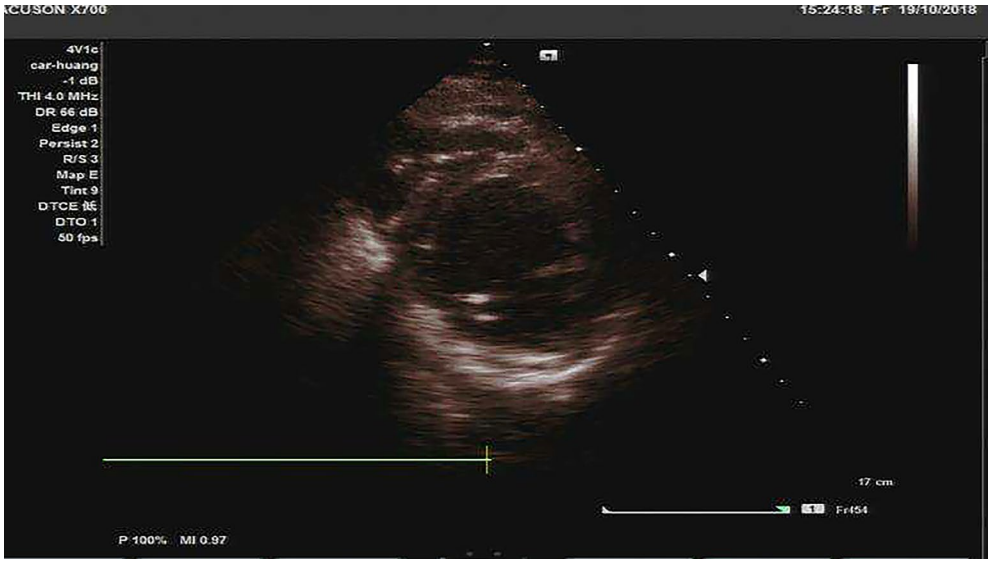

FIGURE 2 | Echocardiographic parasternal short-axis view of ischemic cardiomyopathy.

using the chi-square test. Measurement data with a normal distribution were presented as mean ± standard deviation and compared between groups using the independent sample *t*-test. Receiver operating characteristic (ROC) curve analysis was utilized to determine the threshold value, sensitivity, and specificity of STV in diagnosing NIDCM. A significance level of $p < 0.05$ was considered statistically significant.

3 | Results

3.1 | Comparison of General Data Between the Two Groups

The comparison of baseline data between the two groups revealed that the average age of patients in the NIDCM group was significantly lower than that of the ICM group ($p < 0.05$). Additionally, the diastolic blood pressure in the NIDCM group was significantly higher than in the ICM group ($p < 0.05$). No statistically significant differences were observed in other baseline data between the two groups ($p > 0.05$), as depicted in Table 1.

3.2 | Comparison of Conventional Echocardiographic Indicators Between the Two Groups

There were no statistically significant differences in the conventional echocardiographic indicators between the two groups, including LVEF, LVEDD, LVEDV, EPSS, and SV ($p > 0.05$), as depicted in Table 2.

3.3 | Comparison of STV and RWMA Between the Two Groups

The average STV level in the NIDCM group was significantly higher than that in the ICM group ($p < 0.05$). Additionally, the proportion of significant STV and RWMA in the ICM group were both significantly higher than those in the NIDCM group ($p < 0.05$). Refer to Table 3 for further details.

3.4 | The Diagnostic Value of STV in Differentiating ICM and NIDCM

When the STV was set at 0.768, ROC curve analysis showed a sensitivity of 0.860 and a specificity of 0.948 for distinguishing between NIDCM and ICM, with an area under the curve (AUC) of 0.937. Refer Figure 3 for visualization.

4 | Discussion

DCM is a primary myocardial disease of unknown cause, characterized by the enlargement of the left or right ventricle, or both ventricles, along with impaired ventricular systolic function. This disease progresses slowly, but once it occurs, the condition worsens progressively, ultimately leading to heart failure. Patients often do not notice the disease in its early stages, only becoming aware of it when they exhibit symptoms related to heart failure, such as shortness of breath, chest tightness, and edema [5]. ICM results from prolonged myocardial ischemia caused by coronary atherosclerosis, leading to diffuse myocardial fibrosis, which clinically presents as DCM [6]. Although the clinical manifestations and laboratory tests of ICM and NIDCM are very similar, the treatment principles for the two diseases differ significantly. Therefore, distinguishing between these two conditions poses a clinical challenge [7].

The clinical differentiation between ICM and NIDCM often necessitates coronary angiography to identify any coronary artery blockages. However, this procedure is invasive and the contrast agent used may impact the patient's liver and kidney functions. Moreover, potential complications like hematomas or bleeding at the puncture site can arise [8]. While past research has suggested that magnetic resonance imaging (MRI) can partially distinguish between ICM and NIDCM, its utility is limited [9].

TABLE 1 | Comparison of general data between the two groups.

	NIDCM group ($n=77$)	ICM group ($n=43$)	t/χ^2 value	p value
Age (years)	53.48 ± 9.81	57.95 ± 10.05	2.373	0.019
Gender [cases (%)]			0.709	0.400
Male	49 (63.64%)	24 (55.81%)		
Female	28 (36.36%)	19 (44.19%)		
BMI (kg/m^2)	28.59 ± 4.53	27.94 ± 3.95	0.788	0.432
Clinical symptoms [cases (%)]				
Shortness of breath	51 (66.23%)	30 (69.77%)	0.157	0.692
Chest pain	32 (41.56%)	25 (58.14%)	3.042	0.081
Edema	39 (50.65%)	18 (41.86%)	0.855	0.355
Duration of symptoms (days)	19.47 ± 13.84	20.04 ± 15.42	0.208	0.836
Atrial fibrillation [cases (%)]	8 (10.39%)	5 (11.63%)	0.044	0.834
Heart rate (beats/min)	104.52 ± 19.45	99.17 ± 20.93	1.406	0.162
Systolic blood pressure (mmHg)	145.42 ± 26.53	139.41 ± 25.49	1.207	0.230
Diastolic blood pressure (mmHg)	95.34 ± 13.52	85.66 ± 17.58	3.369	0.001
Comorbidities [cases (%)]				
Hypertension	51 (66.23%)	31 (72.09%)	0.438	0.508
Hyperlipidemia	19 (24.68%)	9 (20.93%)	0.216	0.642
Diabetes	33 (42.86%)	18 (41.86%)	0.011	0.916

TABLE 2 | Comparison of conventional echocardiographic indicators between the two groups.

	NIDCM group ($n=77$)	ICM group ($n=43$)	t value	p value
LVEF (%)	25.64 ± 7.85	26.07 ± 6.42	0.306	0.760
LVEDD (mm)	68.69 ± 7.53	70.51 ± 8.09	1.236	0.219
LVEDV (mL)	237.58 ± 70.53	245.53 ± 73.37	0.584	0.561
EPSS (mm)	24.38 ± 5.04	23.98 ± 6.43	0.377	0.707
SV (mL)	56.44 ± 13.52	55.94 ± 11.74	0.203	0.839

TABLE 3 | Comparison of STV and RWMA between the two groups.

	NIDCM group ($n=77$)	ICM group ($n=43$)	t/χ^2 value	p value
Mean STV	0.86 ± 0.06	0.65 ± 0.12	12.785	0.000
Significant STV [cases (%)]	2 (2.60%)	36 (83.72%)	83.914	0.000
RWMA [cases (%)]	11 (14.29%)	23 (53.49%)	20.883	0.000

Echocardiography currently stands as the most efficient method for assessing cardiac structure and function in clinical settings. Nevertheless, both previous studies [10] and the findings of this study indicate that traditional echocardiographic parameters do not exhibit statistically significant distinctions between ICM and NIDCM patients. This implies that conventional echocardiographic evaluations may not assist in the differentiation of ICM from NIDCM.

The ventricular wall undergoes coordinated movement during cardiac systole and diastole. Recent research indicates that ischemia can disrupt this movement, leading to uncoordinated motion in the affected wall segments during cardiac cycles. This phenomenon, known as RWMA, can be identified through echocardiography [11]. Our study found that RWMA was present in 53.49% of patients with ICM, a significantly higher rate compared to the 14.29% incidence in patients with NIDCM.

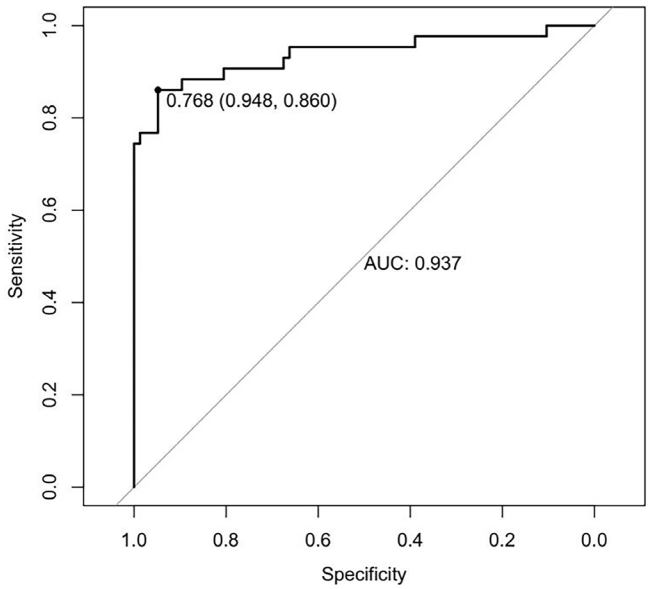

FIGURE 3 | ROC curve for STV in differentiating ischemic and non-ischemic dilated cardiomyopathy.

Ventricular wall thickness, a more objective and easily measurable indicator than wall motion, refers to the thickness of the ventricular wall at a specific point in time. Previous research has shown that patients with ICM, particularly at the apex, have significantly thinner ventricular walls [12]. This thinning is attributed to myocardial ischemia causing necrosis of myocardial cells, which are replaced by scar tissue made of collagen. Furthermore, severe myocardial ischemia can lead to myocardial hibernation, where the affected wall thins due to reduced contractile activity, while the surrounding wall segments thicken compensatorily to maintain function [13, 14]. Patients with ICM often display varying ventricular wall thickness rather than consistent thinning, posing challenges in accurately diagnosing ICM based on single-segment thickness. This study assessed the thickness of different ventricular wall segments at end-diastole across various levels and calculated STV by identifying the thickest and thinnest segments. The findings indicated that the mean STV was significantly lower in the ICM group compared to the NIDCM group, suggesting greater irregularity in ventricular wall thickness among ICM patients, in line with observed pathological changes. Analysis using ROC curves demonstrated that an STV value of 0.768 could effectively differentiate between ICM and NIDCM, with a sensitivity of 0.860 and specificity of 0.948, highlighting the potential of STV as a highly specific and sensitive indicator for distinguishing between the two conditions. Combining STV with RWMA has been proposed to achieve nearly 100% specificity for ICM diagnosis [15]. However, the subjective nature of RWMA assessment raises concerns regarding standardization and reproducibility, necessitating cautious implementation in clinical settings.

In conclusion, this study demonstrates that the measurement of myocardial STV through echocardiography offers a valuable and noninvasive tool for distinguishing between ICM and NIDCM. With high sensitivity (0.860) and specificity (0.948) at a threshold of 0.768, STV proves to be an effective diagnostic indicator. The inclusion of RWMA further enhances diagnostic accuracy, making this approach highly applicable in clinical settings for guiding appropriate treatment strategies without the need for invasive procedures.

Author Contributions

C.X. contributed in the conception, supervision, materials, data collection and/or processing, and writing. D.W. contributed in the design, supervision, analysis and/or interpretation, literature review, and critical review. All authors read and approved the final manuscript.

Ethics Statement

The study was approved by the Ethics Committee of Hospital and was conducted according to the Declaration of Helsinki. All participants were informed in detail about this research and gave their written consent.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the correspondingauthor on reasonable request.

References

1. R. Margiana, A. Markov, A. O. Zekiy, et al., "Clinical Application of Mesenchymal Stem Cell in Regenerative Medicine: A Narrative Review," *Stem Cell Research & Therapy* 13 (2022): 366.

2. S. Wang, T. S. Niu, and X. D. Li, "Different Echocardiographic Features of Ischemic Cardiomyopathy and Dilated Cardiomyopathy: A Cohort Study," *Medical Journal of the Chinese People's Armed Police Forces* 28 (2017): 450–454.

3. A. G. Almeida, J. Grapsa, A. Gimelli, et al., "Cardiovascular Multimodality Imaging in Women: A Scientific Statement of the European Association of Cardiovascular Imaging of the European Society of Cardiology," *European Heart Journal Cardiovascular Imaging* 25 (2024): e116–e136.

4. Echocardiography Group of Ultrasound Medicine Branch in Chinese Medical Association, "Guidelines for Measuring Echocardiography in Chinese Adults," *Chinese Journal of Medical Ultrasound* 25 (2016): 645–666.

5. M. De Luca, G. Crisci, G. Armentaro, et al., "Endothelial Dysfunction and Heart Failure With Preserved Ejection Fraction: An Updated Review of the Literature," *Life (Basel)* 14 (2023): 30.

6. T. M. Stougiannou, K. C. Christodoulou, I. Dimarakis, D. Mikroulis, and D. Karangelis, "To Repair a Broken Heart: Stem Cells in Ischemic Heart Disease," *Current Issues in Molecular Biology* 46 (2024): 2181–2208.

7. S. Fennira, I. Zairi, Z. Jnifene, et al., "Differences Between Idiopathic and Ischemic Dilated Cardiomyopathy," *La Tunisie Médicale* 94 (2016): 535–540.

8. G. G. Stefanini, F. Alfonso, E. Barbato, et al., "Management of Myocardial Revascularisation Failure: An Expert Consensus Document of the EAPCI," *EuroIntervention* 16 (2020): e875–e890.

9. R. J. Holtackers, T. Emrich, R. M. Botnar, M. E. Kooi, J. E. Wildberger, and K. F. Kreitner, "Late Gadolinium Enhancement Cardiac Magnetic Resonance Imaging: From Basic Concepts to Emerging Methods," *Röfo* 194 (2022): 491–504.

10. L. Y. Geng and F. Zhuang, "Differential Diagnostic Analysis of Ischemic Cardiomyopathy Versus Dilated Cardiomyopathy by Color

Doppler Echocardiography," *Journal of Imaging Research and Medical Applications* 1 (2017): 75–76.

11. A. J. Moon-Grady, M. T. Donofrio, S. Gelehrter, et al., "Guidelines and Recommendations for Performance of the Fetal Echocardiogram: An Update From the American Society of Echocardiography," *Journal of the American Society of Echocardiography* 36 (2023): 679–723.

12. Y. J. Zhang, "Analysis of Differential Value of Color Doppler Echocardiography Between Ischemic Cardiomyopathy and Dilated Cardiomyopathy," *Qinghai Medical Journal* 53 (2023): 42–45.

13. Z. Sun, Z. Yun, J. Lin, et al., "Comprehensive Mendelian Randomization Analysis of Plasma Proteomics to Identify New Therapeutic Targets for the Treatment of Coronary Heart Disease and Myocardial Infarction," *Journal of Translational Medicine* 22 (2024): 404.

14. M. Tarascio, L. A. Leo, C. Klersy, R. Murzilli, T. Moccetti, and F. F. Faletra, "Speckle-Tracking Layer-Specific Analysis of Myocardial Deformation and Evaluation of Scar Transmurality in Chronic Ischemic Heart Disease," *Journal of the American Society of Echocardiography* 30 (2017): 667–675.

15. T. A. McDonagh, M. Metra, M. Adamo, et al., "ESC Guidelines for the Diagnosis and Treatment of Acute and Chronic Heart Failure," *European Heart Journal* 42 (2021): 3599–3726. Erratum in: Eur Heart J 2021;42:4901.