Assessment of Heart Failure with Preserved Systolic Function Using Two-dimension Speckle Tracking Echocardiography

Original Article

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ABSTRACT

Background: Heart failure (HF) is characterised as a multifaceted clinical condition linked to either a functional or structural reduction in ventricular blood filling or ejection capability. In numerous countries, this condition is typically the most frequently diagnosed in individuals aged 65 or above.

Aim: To assess the importance of speckle tracking in assessing patients with heart failure who have a preserved ejection fraction.

Methods: This prospective cohort study, comprising 200 patients aged 18-70 years, including both sexes with heart failure and a preserved ejection fraction, employed transthoracic speckle tracking echocardiography (STE). Echocardiography, specifically transthoracic echocardiography and stress echocardiography was evaluated for all patients.

Results: The mean value of left ventricular (LV) end-diastolic dimension was 47.76±8.3 mm, LV end-systolic dimension was 24.07 ±5.9 mm and LV ejection fraction was 59.28 ±7.18 %. Regarding speckle tracking parameters, the mean value of global strain was -16.4 ±1.16 % and global strain rate was 1.2±0.46). HF with preserved ejection fraction score (HFpEF) was low in 132 (66%) patients, Intermediate in 46 (23%) patients and high in 22 (11%) patients with median 1 (0-3). Global strain and global strain rate (%) can significantly diagnosis of HF with preserved ejection fraction respectively at cut-off >-18.5 and ≤1.79) with 96.50% and 89.00% sensitivity, 51.50% and 60.50% specificity.

Conclusions: Speckle tracking can be a useful tool for the diagnosis of HF with HFpEF.

Key Words: Heart failure, systolic function, speckle tracking echocardiography, transthoracic echocardiography.

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INTRODUCTION

As the population ages, the incidence of patients with heart failure (HF) is increasing, accompanied by considerable illness and death rates [1].

The most frequent diagnosis in patients aged 65 years or older is often found in numerous countries [2]. By 2030, it is projected that HF occurrences were rised by 46%, resulting in approximately 970,000 new cases annually. Heart failure is characterised by a complex clinical condition associated with either impaired function or structural damage affecting the heart's ability to fill or pump blood properly [3, 4].

The primary forms of heart failure classification are determined by issues with systolic and diastolic function. Patients with a left ventricle ejection fraction (LVEF) of less than 40% typically have an enlarged heart and are subsequently diagnosed with heart failure with reduced ejection fraction (HFrEF). A patient showing a left ventricular ejection fraction of 50% or more has an issue with the filling properties, and a diagnosis of heart failure with preserved ejection fraction (HFpEF) is made [4, 5].

The definition of HF has now expanded to include HFpEF as borderline (EF40-49%) and HFpEF improved (EF more than 50%). Approximately 50% of patients with this condition suffer from HFpEF due to associated risk factors like aging, high blood pressure, being overweight, and coronary artery disease [6, 7]. Echocardiography relies heavily on accurate and precise diagnostic assessments of the myocardium.

Two-dimensional echocardiography is employed to visually assess the functioning of the left ventricle in heart failure patients. Echocardiogram readings are often subjective and provide semi-quantitative outcomes.

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Speckle-tracking echocardiography, a more advanced software package, offers superior measurement capabilities for assessing both regional and global left ventricular systolic and diastolic function [8].

Clinicians and researchers can now more effectively assess the left atrium, a vital aspect to be measured in heart failure, thanks to advancements in imaging and software technology [9].

Recent developments in the use of STE to visualise the LA and LV and measure myocardial deformation have made it possible to evaluate the myocardium in patients with HFpEF with greater accuracy.

Using STE to detect diastolic dysfunction early was improved doctors' understanding and management of heart failure with preserved ejection fraction (HFpEF)symptoms.

This study's main goal was to determine if speckle tracking is helpful in assessing heart failure with intact ejection fraction.

PATIENTS AND METHODS

This prospective cohort study involved 200 patients between the ages of 18 and 70, comprising both sexes, with heart failure (HF) characterized by a preserved ejection fraction, underwent transthoracic speckle tracking echocardiography (STE) as well as a H2FPEF score, which calculated the probability of underlying HF.

ETHICAL CONSIDERATION

The study was conducted following approval from our Ethical Committee (Approval code:35682/8/22). Written consent was secured from the patients after they had been fully informed.

Exclusion criteria consisted of patients with normal coronary angiography results, regional wall motion abnormalities, more than mild valvular heart disease, a poor echo window, patients with acute coronary syndrome, systolic left ventricular dysfunction, and chronic kidney disease with a creatinine clearance of less than 60 mL/min.

A comprehensive assessment was performed on all patients, which included a detailed medical history, a thorough physical examination, and laboratory tests [such as kidney function tests (measuring urea and creatinine levels) and blood glucose tests]. Additionally, radiological examinations [including transthoracic echocardiography (TTE)] were also conducted.

Transthoracic echocardiography:

It took TTE roughly an hour. On an examination table, patients recline and have small electrode patches affixed to various areas of their chest to capture heart rate and rhythm readings. A medic then applies a specific gel to the patient's skin to facilitate sound transmission. The gel is followed by the placement of an ultrasound device, a transducer, which is gently pressed against the patient's skin and systematically moved around. A transducer resembles a typical microphone. The device transmits sound waves and records the reflections, instructing the patient to remain stationary and manipulate their breathing or positioning to capture alternative or enhanced images.

Speckle tracking echocardiography

Using speckle-tracking software, single-wall recordings were used to determine saturn deformation. With the exception of the apical cap, the region of interest was established along the endocardial boundary from base to apex and was modified in accordance with the different wall thicknesses. The software's speckle-tracking was manually examined and adjusted as necessary. Global wall deformation, computed throughout the wall's whole length, was used in the research. The classification of septal deformation patterns was based on the sequence of septal shortening and stretching [10].

The following measures were made: speckle tracking, which measured global strain and global strain rate; conventional echocardiogram, which included ejection fraction; and left ventricular end-diastolic volume (LVEDV) and left ventricular end-systolic volume (LVESV).

We calculated the H2FPEF score for each outpatient and divided them into three groups: Low score: [0–1 point], intermediate: [2–5 points] and high: [6–9 points].

Statistical analysis

IBM Inc., Chicago, IL, USA's SPSS v26 completed the measurable investigation. The ordinariness of the information circulation was evaluated using histograms and the Shapiro-Wilks test. The mean and standard deviation (SD) were introduced as quantitative parametric data. The middle and interquartile ranges (IQR) were presented as quantitative non-parametric data. Subjective factors were introduced as recurrence and rate (%). Roc bend was utilized for assessment of analytic execution responsiveness, explicitness, positive prescient worth (PPV) and negative prescient worth (NPV).

Table 1: Demographic data, medical history, HR and MAP of the studied patients.

		N=200
Age (years)		45.3 ± 14.02
Sex	Male	93 (46.5%)
	Female	107 (53.5%)
Weight (Kg)		71.6 ± 8.44
Height (m)		1.7 ± 0.1
BMI (kg/m^2)		24.6 ± 3.92
Medical history	Smoker	28 (14%)
	CAD	75 (37.5%)
	Hypertension	167 (83.5%)
	DM	115 (57.5%)
HR (bpm)		74.1 ± 15.82
MAP (mmHg)		91 ± 15.24

Data are presented as mean ± SD or frequency (%). BMI: Body mass index, CAD: Coronary artery disease, DM: Diabetes mellitus, AF: Atrial fibrillation, HR: Heart rate, MAP: Mean arterial blood pressure.

RESULTS

Table 2: Laboratory data of the studied patients.

	N=200
Hb (g/dL)	11.9 ± 2.39
Creatinine (µmol/L)	119.3 ± 69.14

Data are presented as mean ± SD. Hb: hemoglobin.

Demographic data, medical history, HR and MAP ere enumerated in this table. (Table 1)

The mean value of Hb was 11.92 ±2.39 g/dL and creatinine were 119.27±69.14 µmol/L. (Table 2)

Table 3: H2FPEF score of the studied patients.

	N=200
H2FPEF score	1(0-3)
Low	132 (66%)
Intermediate	46 (23%)
High	22 (11%)

Data are presented as median (IQR) or frequency (%).

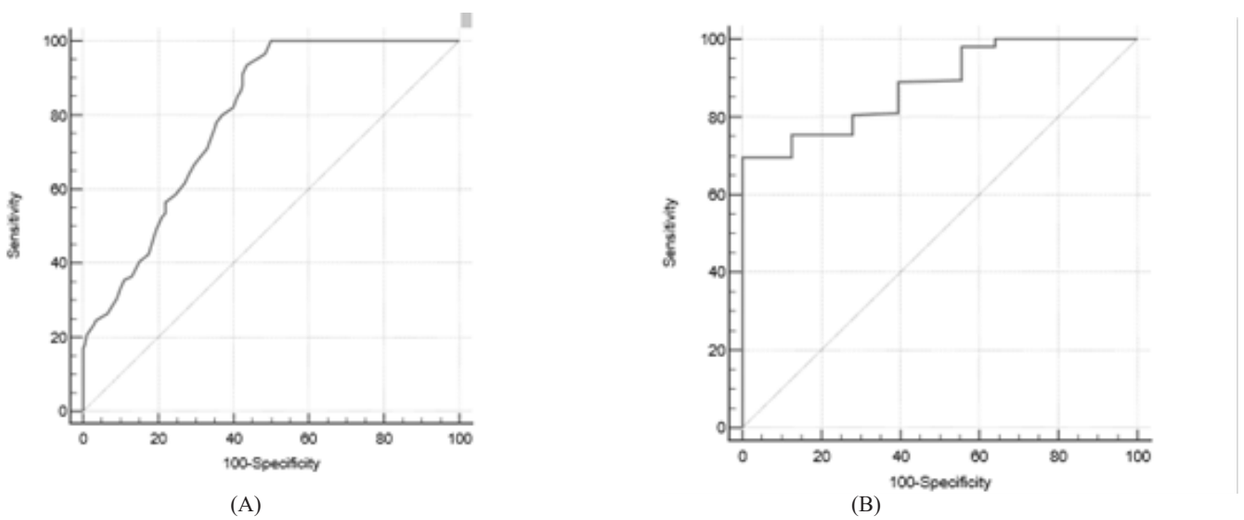
H2FPEF score was low in 132 (66%) patients, Intermediate in 46 (23%) patients and high in 22 (11%) patients with median 1 and IQR 0-3. (Table 3)

Table 4: Global clinical and echocardiographic characteristics and Speckle tracking parameters of the studied patients

	N=200
LVEDD (mm)	47.8 ± 8.3
LVESD (mm)	24.1 ± 5.9
LVEF (%)	59.3 ± 7.18
Speckle tracking parameters	
Global strain	-16.4 ± 1.16
Global strain rate (%)	1.2 ± 0.46

Data are presented as mean ± SD. LVEF: Left ventricular ejection fraction, LVESD: Left ventricular end-systolic diameter, LVEDD: left ventricular end-diastolic dimension.

The mean value of LVEDD was 47.76±8.3 mm, LVESD was 24.07 ±5.9 mm, and LVEF was 59.28 ±7.18 %. Regarding speckle tracking parameters, the mean value of global strain was -16.4 ±1.16 % and global strain rate was 1.2±0.46). (Table 4)

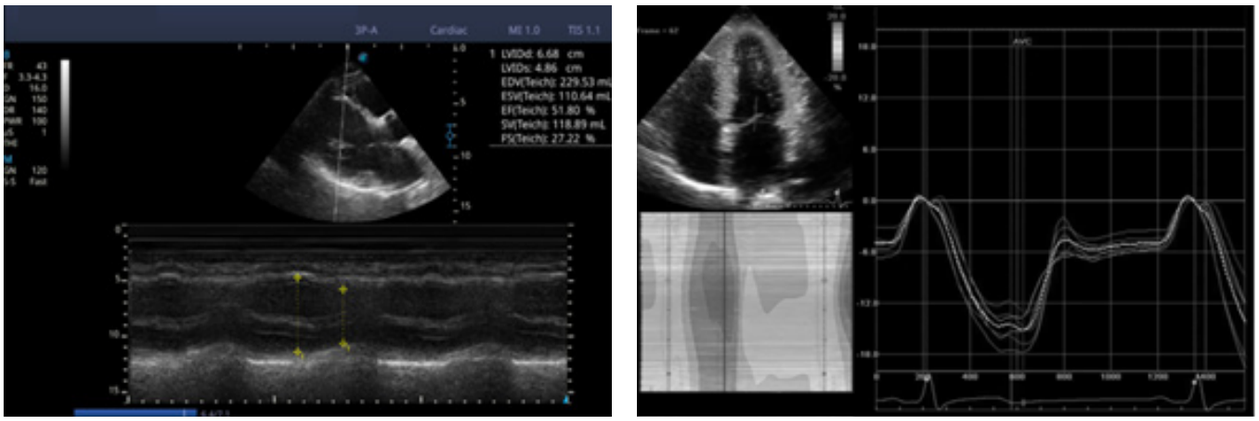


(A) (B)

Fig. 1: ROC curve of (A) global strain and (B) global strain rate (%) in diagnosis of heart failure with preserved ejection fraction.

Global strain and global strain rate (%) can significantly diagnosis of HF with preserved ejection fraction respectively (AUC = 0.793 and 0.883) at cut-off >-18.5 and ≤1.79) with 96.50% and 89.00% sensitivity, 51.50% and 60.50% specificity, 66.6% and 69.3% PPV and 93.6% and 84.6% NPV. (Figure 1)

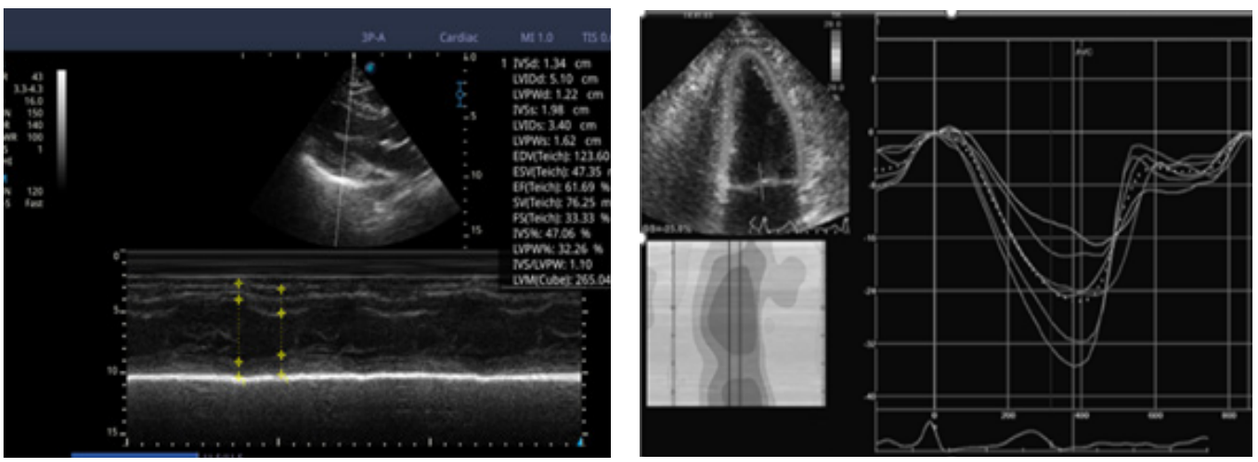
Case 1: Female patient 51 years old came to our echo lab at Tanta University to do echo study; her complaint was exertional dyspnea and had past history of hypertension on beta blocker drug. She included to our study as she did not have any exclusion criteria. The patient was 76 kg weight and 1.56-meter height. Clinical examination revealed



(A) (B)

Fig. 2: (A) regular transthoracic echo left ventricular end-diastolic dimension, left ventricular end-systolic dimension and ejection fraction and (B) speckle tracking longitudinal global strain -15.2 %.

Case 2: Male patient 55 years old smoker, with past history DM, HTN came to Tanta University to do echo study, after history taking, he was matching inclusion criteria for our study. Patient was 60 kg, 1.64 m. Patient clinical data was HR 79b\min, BP 140\90 mmhg, mean arterial BP115. TTE was done, and data collected as following: regular transthoracic echo LVH, LVEDD 51, LVESD 34, EF 61.69 %. (Figure 3, A) Speckle tracking data LV longitudinal global strain -25.0%, global strain rate 1.5 (Figure 3, B)



(A) (B)

Fig. 3: (A) regular transthoracic echo left ventricular end-diastolic dimension, left ventricular end-systolic dimension and ejection fraction and (B) speckle Tracking longitudinal global strain.

that HR was 84 b\min; BP was 120\70 mmhg, with mean arterial blood pressure 95. Patient informed about the study and wrote the consent to precede TTE. Regular echo data came LVEDD 66, LVESD 48, EF 51.8 %. (Figure 2, A) Speckle tracking data was LV Longitudinal global strain -15.2 %. (Figure 2, B)

DISCUSSION

In high-income countries, Hypertrophic Cardiomyopathy (HF) is the most frequent diagnosis in patients aged 65 years or older. Heart failure is commonly described as a multifaceted clinical condition resulting from complications affecting either the proper functioning or the structural integrity of the ventricles' ability to fill or pump blood [11].

In our study, the LVEDD ranged from 34 to 62 mm with a mean value (± SD) of 47.76 (±8.3) mm. The LVESD ranged from 9 to 37 mm with a mean value (± SD) of 24.07 (±5.9) mm. ranged from 34 to 62 mm with a mean value (± SD) of 47.76 (±8.3) mm. The LVEF ranged from 47.1 to 71.1 % with a mean value (± SD) of 59.28 (±7.18) %. Research by ***Baral et al.*** [12] supports the findings, consisting of 240 participants, 158 of whom had hypertension (with an average age of 48.5±6.1 years, 50.6 percent female) and 82 control subjects who were healthy (with an average age of 45.62±6.3 years and 51.2 percent female). Patients with high blood pressure showed significantly greater thickness in the posterior wall of their hearts and had a relatively thicker heart wall compared to other parts of their hearts ($P < 0.001$). The hypertensive group also had a significantly higher left ventricular mass index. There was no discernible difference between the two groups' global left ventricular ejection fractions (LVEFs). ***Ayoub et al.*** [13] observed a similar trend, with global LVEF not showing significant differences in hypertensive patients across the two subgroups.

In our study, the global strain ranged from -18.5 to -14.6% with a mean value (± SD) of -16.4 (±1.16) %. The global strain rate ranged from 0.32 to 1.97 with a mean value (± SD) of 1.2 (±0.46). According to a meta-analysis by ***Morris et al.*** [11], patients with HFpEF had significantly lower GLS values when their longitudinal systolic function of the left ventricle was evaluated using 2DSTE than did control subjects, and an abnormal GLS reading was often seen. In agreement with ***Bshiebish et al.***[14] patients with HFpEF were found to have left ventricular systolic dysfunction identified through the use of global longitudinal strain (GLS).

In our study, global strain can significantly diagnosis of HF with preserved ejection fraction ($P < 0.001$ and AUC = 0.793) at cut-off >-18.5 with 96.50% sensitivity, 51.50% specificity, 66.6% PPV and 93.6% NPV. Global strain rate (%) can significantly diagnosis of HF with preserved ejection fraction ($P < 0.001$ and AUC = 0.883) at cut-off ≤1.79 with 89.00% sensitivity, 60.50% specificity, 69.3% PPV and 84.6% NPV. ***Dokainish et al.*** research [15] shows that longitudinal systolic myocardial strain and strain rate are lower in patients with preserved left ventricular ejection fraction (LVEF) and elevated left ventricular filling pressures than in patients with preserved LVEF and normal left ventricular filling pressures. This suggests that patients with preserved ejection fraction have abnormal systolic conditions.

Bshiebish et al. [14] discovered that even when the left ventricular ejection fraction is maintained, significant left ventricular systolic dysfunction may be identified by global longitudinal strain, with an area under the curve of 0.9875 obtained from a receiver operating characteristic curve study.

The study had some limitations, including a very small sample size and a brief follow-up time. The predictive usefulness of speckle tracking in heart failure with preserved ejection fraction (HFpEF) was not assessed in this single-center investigation.

CONCLUSIONS

Speckle tracking can be a useful tool for the diagnosis of HF with preserved ejection fraction (HFpEF). Speckle tracking can be a valuable addition to the diagnostic workup of HFpEF

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REDUNDANT OR DUPLICATE PUBLICATION

This paper has not been published in its current form or substantially similar form elsewhere including on a web site and, it has not been accepted for publication elsewhere.

CONFLICTS OF INTEREST

There is no conflicts of interest.

AUTHORS' CONTRIBUTION

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [M. G. E.], [M. A. E.], [A. M. A.] and [S. M. S.]. The first draft of the manuscript was written by [M. G. E.] and all authors commented on previous versions of the manuscript. All authors read and approved of the final manuscript.

REFERENCES

1. **Magnussen C, Blankenberg S.** Biomarkers for heart failure: small molecules with high clinical relevance. J Intern Med. 2018;283 (6):530-43.

2. **Braunwald E.** The war against heart failure: the Lancet lecture. Lancet. 2015;385 (99):812-24.

3. **Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, *et al.*** Heart disease and stroke statistics—2017 update: a report from the American Heart Association. Circ. 2017;135 (10):146-53.

4. **Smith KR, Hsu CC, Berei TJ, Aldemerdash A, Hollis IB, Vardeny O, *et al.*** PARADIGM-HF trial: Secondary analyses address unanswered questions. Pharmacotherapy. 2018;38 (2):284-98.

5. **Yancy CW, Jessup M, Bozkurt B, Butler J, Casey Jr DE, Colvin MM, *et al.*** 2017 ACC/AHA/HFSA focused update of the 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Failure Society of America. Circ. 2017;136 (6):137-61.

6. **Gladden JD, Chaanine AH, Redfield MM.** Heart failure with preserved ejection fraction. Annu Rev Med. 2018;69 (20):65-79.

7. **Abebe TB, Gebreyohannes EA, Tefera YG, Abegaz TM.** Patients with HFpEF and HFrEF have different clinical characteristics but similar prognosis: a retrospective cohort study. BMC Cardiovasc Disord. 2016;16 (1):232-339.

8. **Roger VL. Epidemiology of heart failure.** Circ Res. 2013;113 (6):646-59.

9. **Opdahl A, Helle-Valle T, Skulstad H, Smiseth OA.** Strain, strain rate, torsion, and twist: echocardiographic evaluation. Curr Cardiol Rep. 2015;17 (4):1-14.

10. **Maréchaux S, Guiot A, Castel AL, Guyomar Y, Semichon M, Delelis F, *et al.*** Relationship between two-dimensional speckle-tracking septal strain and response to cardiac resynchronization therapy in patients with left ventricular dysfunction and left bundle branch block: a prospective pilot study. J Am Soc Echocardiogr. 2014;27 (5):501-11.

11. **Morris DA, Ma XX, Belyavskiy E, Aravind Kumar R, Kropf M, Kraft R, *et al.*** Left ventricular longitudinal systolic function analysed by 2D speckle-tracking echocardiography in heart failure with preserved ejection fraction: a meta-analysis. Open Heart. 2017;4 (2):55-65.

12. **Baral BR, Maskey A, Malla R, Rajbhandari S, Adhikari KC, Bhandari S, *et al.*** Evaluation of left ventricular systolic function by myocardial deformation imaging in hypertensive patients with preserved left ventricular ejection fraction. Nepal Heart J. 2021;18 (2):15-9.

13. **Ayoub AM, Keddeas VW, Ali YA, El Okl RA.** Subclinical lv dysfunction detection using speckle tracking echocardiography in hypertensive patients with preserved lv ejection fraction. Clin Med Insights Cardiol. 2016;10 (2):85-90.

14. **Bshiebish HAH, Al-Musawi AH, Khudeir SA.** Role of global longitudinal strain in assessment of left ventricular systolic function in patients with heart failure with preserved ejection fraction. J Saudi Heart Assoc. 2019;31 (2):100-5.

15. **Dokainish H, Sengupta R, Pillai M, Bobek J, Lakkis N.** Usefulness of new diastolic strain and strain rate indexes for the estimation of left ventricular filling pressure. Am J Cardiol. 2008;101 (10):1504-9.

تقييم قصور القلب مع الحفاظ على وظيفة الانقباض باستخدام تخطيط صدى القلب ثنائي الأبعاد بتقنية تتبع البقع

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الخلفية: يُوصف قصور القلب بأنه حالة سريرية متعددة الجوانب، مرتبطة إما بانخفاض وظيفي أو هيكلي في قدرة البطين على ملء الدم أو قذفه. في العديد من البلدان، تُشخَّص هذه الحالة عادةً لدى الأفراد الذين تبلغ أعمارهم ٦٥ عامًا فأكثر.
الهدف: تقييم أهمية تتبع النقاط في تقييم مرضى قصور القلب الذين لديهم نسبة قذف محفوظ.
الطرق: شملت هذه الدراسة الاستطلاعية ٢٠٠ مريض تتراوح أعمارهم بين ١٨ و٧٠ عامًا، من كلا الجنسين، يعانون من قصور القلب ونسبة قذف محفوظ. تم تقييم تخطيط صدى القلب، وتحديدًا تخطيط صدى القلب عبر الصدر وتخطيط صدى القلب الإجهادي، لجميع المرضى.
النتائج: بلغ متوسط قيمة البعد الانقباضي للبطين الأيسر ٤٧,٧٦±٨,٣ مم، و٢٤,٠٧±٥,٩ مم، ونسبة القذف ٥٩,٢٨±٧,١٨٪. وفيما يتعلق بمعايير تتبع البقع، بلغ متوسط قيمة الإجهاد الكلي -١٦,٤±١,١٦٪، وبلغ معدل الإجهاد الكلي ١,٢±٠,٤٦٪. كان قصور القلب مع الحفاظ على نسبة القذف (HFpEF) منخفضًا لدى ١٣٢ مريضًا (٦٦٪)، ومتوسطًا لدى ٤٦ مريضًا (٢٣٪)، ومرتفعًا لدى ٢٢ مريضًا (١١٪)، بمتوسط ١ (٠-٣). يمكن للإجهاد الكلي ومعدل الإجهاد الكلي (٪) تشخيص قصور القلب مع الحفاظ على كسر القذف عند حد فاصل >-١٨,٥ و≤١,٧٩، على التوالي، بحساسية ٩٦,٥٠٪ و٨٩,٠٠٪، وخصوصية ٥١,٥٠٪ و٦٠,٥٠٪.
الخلاصة: يمكن أن يكون تتبع البقع أداة مفيدة لتشخيص قصور القلب مع قصور القلب مع الحفاظ على الجزء المقذوف من القلب.