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Evaluation of Left Ventricular Remodelling in Patients with Anterior Myocardial Infarction According to Sphericity and Conicity Indices and their Association with Left Ventricular Function

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تقييم إعادة تشكيل البطين الأيسر في المرضى الذين يعانون من احتشاء عضلة القلب الأمامي حسب مؤشرات الكروية والمخروطية وارتباطها بوظيفة البطين الأيسر

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ABSTRACT

Background:

Following cardiac damage, a complex process known as left ventricular adverse remodelling occurs, which is characterized by alterations in the left ventricle (LV)'s structure, form, and function. The study aims at assessing the significance of the LV sphericity index in quantifying LV geometric alterations, as well as the conicity index's significance in recognizing regional variations in LV geometry and evaluating its relation to the heart's systolic and diastolic function.

Methods and Methods: A total of 50 individuals with anterior myocardial infarction (MI) participates in this cross-sectional study. Sphericity (SI) and conicity indices (CI) are calculated using the ratios of the short axis and long axis, and the apical to short LV axis, respectively. Then measurements of the LV's systolic and diastolic functioning are done.

Results: The sphericity index and systolic parameters display a statistically significant negative correlation ($P<0.05$). The conicity index and systolic parameters show a statistically non-significant negative correlation ($P>0.05$).

The relation between CI and SI with LV diastolic parameters reveal a positive correlation, but it was statistically non-significant ($p>0.05$). Only the left atrial volume index (LAVI) was statistically significant with SI ($p<0.05$).

Conclusion: This study concludes that LV indices are a simple, non-invasive measure of LV remodelling, whether locally by CI or globally by SI, and can reflect the LV's systolic and diastolic performance based on correlation studies.

Keywords: Sphericity index, conicity index, anterior myocardial infarction.

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INTRODUCTION:

Post-infarct ventricular remodelling occurs in around 30% of patients with a previous anterior MI and 17% of patients with a non-anterior infarct [1]. Expansion, extension of the infarction into neighboring myocardial tissue which is not infarcted, and hypertrophy of the remote left ventricle are the mechanisms that cause LV remodelling after MI [2].

Post-infarct ventricular remodelling is defined by an enlargement of the left ventricular chamber, transforming its elliptical shape into a more spherical one [3]. An increase in the sphericity index reflects this change. To evaluate this distortion, a number of geometrical indexes have proposed, including the sphericity and conicity indexes.

LV geometric alterations can be quickly, easily, and consistently measured using the left ventricular sphericity index [4]. Since SI cannot identify the local shape abnormalities at the apical area following anterior MI, which occur prior to global ventricular dilatation, the conicity index is provided as a straightforward tool to address this localized change [5]. The sphericity index is acknowledged as a reliable indicator of LV remodelling [6 and 7].

The study aims at assessing the significance of the LV sphericity index in quantifying LV geometric alterations, as well as the conicity index's significance in recognizing regional variations in LV geometry and evaluating its relation to the heart's systolic and diastolic function.

MATERIAL AND METHODS:

50 individuals (41 men and 9 women) with an old anterior MI and ages ranging from 35 to 60 years were included in this cross-sectional study. From the beginning of September 2022 to the end of February 2023, this study was carried out in Al-Hilla City's Merjan Medical City and Shaheed Almehrab Cardiac Catheterization Center. Echocardiography was used in the investigation, 2D and Doppler images were taken for all patients.

The long axis is determined by calculating the distance from the apex of the left ventricle to the center of the mitral valve in the apical 4-chamber view, obtained at the end of diastole, while the short axis was calculated from the axis that vertically intersected the midpoint of the long axis. The sphericity index was then derived from the ratio of the short to the long axis, as shown in **figure 1.**

The conicity index, taken in the same view, is the ratio of the apical to the short axis, where the apical axis is the diameter of the circle that coincides with the apex, as illustrated in **figure 1.**

Left ventricular ejection fraction (EF), left ventricular volumes, and LA volume were calculated by Simpson method, **figure 2**. The stroke volume (SV) is derived

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from the LV volumes using the following formula: Stroke volume = left ventricular end diastolic volume (LVEDV) – left ventricular end systolic volume (LVESV).

Pulsed wave doppler at the leaflet tips of the mitral valve was employed to identify the E wave, and by using tissue doppler imaging, the mean of e' of both medial and lateral sides was calculated as demonstrated in **figure 3**, then the E/e' ratio was computed.

Tricuspid regurgitant (TR) velocity is assessed using continuous wave doppler.

The mitral valve's tenting area, which is the region enclosed by the valve leaflet tips and annular plane, is assessed at mid-systole. The length between the leaflet tips and the annular plane is also measured, as shown in **figure 4,** and is known as the mitral valve's tenting height.

By using color doppler on the mitral valve, the vena contracta is measured, which represents the breadth of the jet close to the regurgitant orifice.

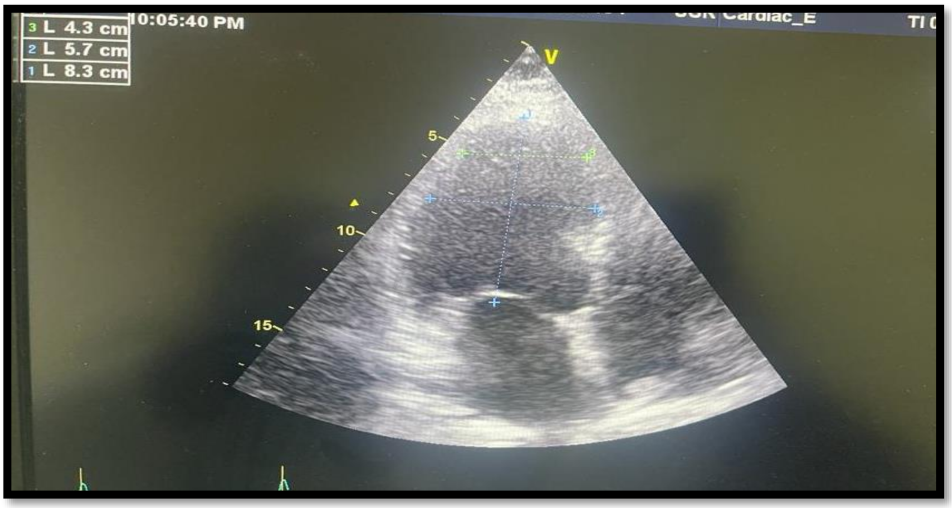

Figure 1. Measuring the apical, long, and short axes of left ventricle in the apical four champer view.

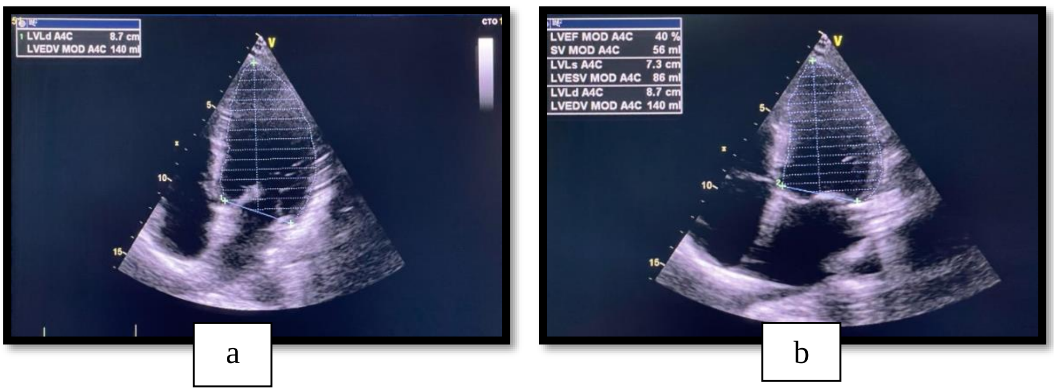

Figure 2. Ejection fraction measurement using the Simpson method at the (a) end diastolic, and (b) end systolic.

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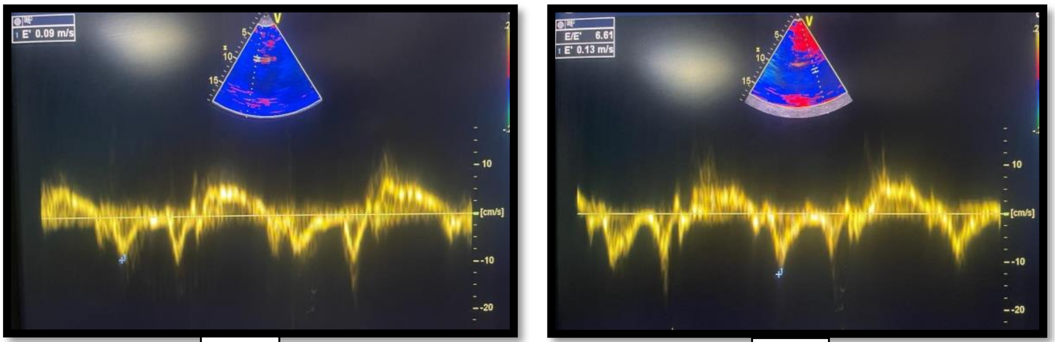

a a

Figure 3. Pulsed tissue doppler imaging at the (a) septal, and (b) lateral mitral annulus.

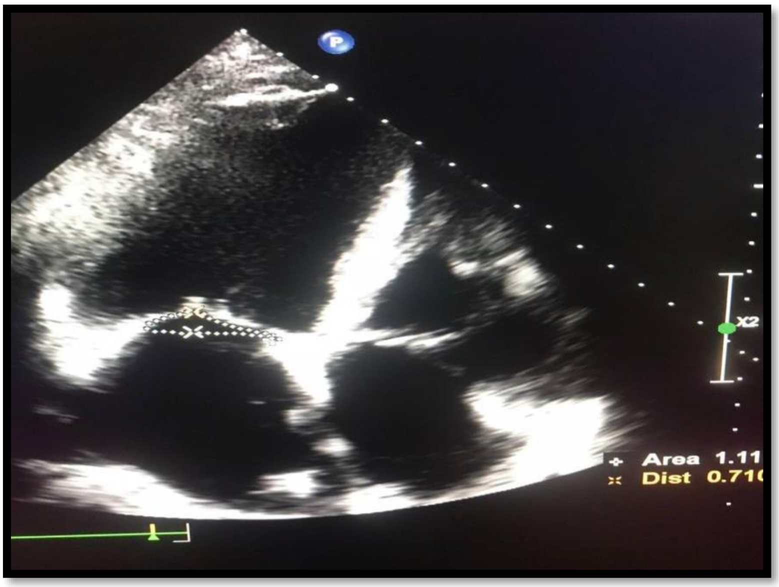

Figure 4. Measurement of the mitral valve's tenting area and height.

STATISTICAL ANALYSIS

SPSS-23 was used to analyze the obtained data, and all results are represented as the mean along with the standard deviation. The data was normally distributed which evaluated by the Kolmogorov-Smirnov tests. Continuous variables were compared using an independent t-test. Pearson's (r) correlation coefficients were utilized to evaluate the correlation between various variables. P value of 0.05 is considered statistically significant.

Ethical approval: This study receives approval from Babylon University/College of Medicine's publishing ethics committee, and verbal consent from the participants was obtained.

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RESULTS

The mean of the sphericity index was 0.58±0.11, the mean of the conicity index was 0.69±0.12. Other demographic data, echocardiographic measurements, are presented in **table 1** as mean ± standard deviation.

Table 1. The demographic data, 2D echocardiographic parameters, values are presented as mean ± SD.

Parameters	Mean	Standard deviation
Age	59.2	5.597
Body mass index	28.44	4
Body surface area	1.97	0.16
long axis dimension	8.9	0.79
Short axis dimension	5.17	0.98
apical dimension	3.54	0.73
Sphericity index	0.58	0.11
Conicity index	0.69	0.12
Ejection fraction	40%	0.09
Stroke volume	59.82	19.5
EDV	158.18	63.3
ESV	98.36	51.5
E/A	1.46	1.24
E/e'	13.03	7.9
LA volume index	24.23	15.62
TR velocity	1.60	1.13
Tenting area of MV	1.45	1.06
Cooptation distance MV	0.79	0.22
VC of MR	0.25	0.16

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As shown in **table 2,** correlation studies between CI, SI, and various LV systolic, diastolic, and MR-related measures were conducted.

The sphericity index is found to have a statistically significant negative correlation with EF, SV, EDV, and ESV (P=0.000, 0.025, 0.000, 0.000). The conicity index had a negative correlation but was non-significant with EF, SV, EDV, and ESV ($P > 0.05$).

Concerning the correlation of CI and SI with E/A, E/e', and TR velocity, it exhibits a positive correlation but was statistically non-significant ($P > 0.05$). CI also showed a non significant positive correlation with LAVI (P> 0.05), but SI showed a significant positive correlation with LAVI (P< 0.05), as seen in **table 2**.

SI showed statistically significant positive correlations with MR measures (cooptation distance, and VC of MR, P values=0.001, 0.027 respectively), but non significant positive correlations with MV tenting area, (P=0.072). while there is a non significant correlation between CI and MR parameters (P >0.05).
Patients with mild MR had a lower SI (0.57 ± 0.107) than patients with moderate MR (0.62 ± 0.14) with statistical non significance, p =0.24. The difference in CI between mild and moderate MR is not statistically significant (P=0.624), CI in mild MR= 0.7 ±0.12; CI in moderate MR= 0.67± 0.13), **table 3**.

Table 2. Correlation of conicity and sphericity indices with various echocardiographic parameters.

Parameters	Conicity index		Sphericity index	
	r	P	r	P
Ejection fraction	-0.100	0.486	-0.524**	0.000
Stroke volume	-0.182	0.205	-0.350*	0.025
EDV	-0.135	0.350	0.629**	0.000
ESV	-0.131	0.365	0.667**	0.000
E/A	0.142	0.320	0.053	0.713
E/e'	0.149	0.35	0.18	0.251
LAVI	0.20	0.21	0.33	0.035
TR velocity	0.067	0.668	0.149	0.340
Tentening area	0.042	0.773	0.257	0.072
Cooptation distance	0.052	0.718	0.453**	0.001
Vena contracta	0.186	0.251	0.346*	0.027

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Table 3. Correlation of sphericity and conicity indices with severity of mitral regurgitation

Parameters	Mild MR	Moderate MR	p value
sphericity index	0.57 ± 0.107	0.62 ± 0.14	0.24
conicity index	0.7 ± 0.12	0.67± 0.13	0.624

DISCUSSION:

The sphericity index exhibits a significant positive correlation with ESV and EDV. A significant negative correlation with SV and EF, this is because left ventricular remodelling causes an increase in LV volumes, while systolic dysfunction, represented by a decrease in EF, results from reduced contractility.

This finding agrees with Wong *et al*., who discovered worse LV function with higher sphericity due to decrease contractility [8]. Additionally, it match a study carried out by Tani *et al*. [9]. Studies employing MRI showed that the SI is negatively correlated with LVEF and positively correlated with LV end systolic and diastolic volumes [10 and 11].

A statistically non significant negative correlation was found between the conicity index and EF, SV. This happens as a result of the LV's mid-papillary area contracting, accounts for around two-thirds of the LV stroke volume. Additionally, there is heterogeneity in the amount of myocardial thickness and endocardial excursion in healthy individuals, which is lessened at the apex compared to the base [12 and 13].

Furthermore, CI demonstrated a non-significant negative correlation with EDV and ESV. The reason for this can be explained by the conicity index is the ratio between the apical to the short axis of LV, during the LV remodelling, the short axis is more impacted by LV volume dilation than the apical region, which lowers the CI. This matches the same findings from the tables shown in earlier studies that showed an inverse correlation between the conicity index and the EDV and ESV [5 and 14].

The relationships between CI, SI with LV diastolic measures reveal a positive correlation. To our knowledge there was no previous study that have looked at the relationship between sphericity, conicity index, and diastolic function.

Previous investigations examined the impact of LV remodelling on LV diastolic function following anterior MI. Silveira and his colleagues discovered a greater E/E' ratio in individuals with LV remodelling, and an E/E' ratio of 11.56 predicted ventricular remodelling within 6 months [15]. Flachskampf stated that E/e' was a reliable indicator of remodelling, and LV diastolic pressures are raised quickly after infarction, showing that an ischemia state has altered the diastolic pressure volume relationship of the left ventricle [16].

Adhyapak *et al*. employ relative wall thickness (RWT) as a measure of LV remodelling in individuals with ischemic cardiomyopathy and demonstrated how it correlated with diastolic and systolic performance. They discovered that individuals with lower RWT had more severe LV remodelling, a higher risk of death, and greater systolic and diastolic dysfunction, clarify it by saying that following MI, the LV remodelling can make the LV wall less distensible due to increased stress on the thinner LV wall, which results in volume and pressure overload on non-infarcted LV parts and triggers myocardial fibrosis, which worsens diastolic dysfunction [17].

Positive correlations between the sphericity index and the MR parameters were observed in this study. This is more in line with the studies conducted by Sadeghpour *et al*. and Di Donato *et al*. [18 and 5].

The association between CI and MR parameters is not statistically significant. This is comparable to the work by Di Donato *et al*. [5].

This study reveals that patients with mild MR had a lower SI than patients with moderate MR. This is related to LV remodelling, which causes dilatation of the annulus, tethering, and displacement of the mitral valve leaflet, resulting in a decline in its competence. Therefore, if the sphericity index increases, more MR occurs [14]. The sphericity index and the degree of MR are found to be statistically significantly correlated in other investigations [14,18 and 19]. The contradictory research showed that the sphericity index and MR did not correlate well [20].

This study revealed that the difference in CI between mild and moderate MR is not statistically significant. This may be because the conicity index represents localized abnormalities that are not mitral valve-related. This is consistent with Di Donato *et al*.'s interpretation, which goes as follows: The apex widens when the conicity index is high, but the short axis remains unchanged, resulting in a better mitral function [5]. Garatti *et al*. discover no link between the severity of MR and CI [14].

CONCLUSION:

This study concludes that LV indices are a simple, non-invasive measure of LV remodelling, whether locally by CI or globally by SI, and can reflect the LV's systolic and diastolic performance based on correlation studies. Additionally, SI, not CI, affects the secondary MR.

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Conflict of interests

There are non-conflicts of interest.

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الخلاصة

المقدمة: إعادة تشكيل البطين الأيسر عملية معقدة تتميز بتغيير هيكل البطين وشكله الناتج عن إصابة القلب ويؤدي أيضا إلى تغييرات في وظيفة القلب. تهدف هذه الدراسة إلى تقييم دور مؤشر الكروية في القياس الكمي للتغيرات الهندسية للبطين الأيسر، بجانب دور مؤشر المخروطية في عكس التغيرات المناطقية في البطين الايسر ودراسة علاقته بالعمل الانقباضي والانبساطي للقلب.

طرق العمل: شارك في هذه الدراسة المستعرضة 50 فردا يعانون من احتشاء عضلة القلب الأمامي, تم قياس مؤشر الكروية من النسبة بين المحور القصير والمحور الطويل و مؤشر المخروطية من النسبة بين المحور القمي إلى المحورالقصير للبطين الايسر, ثم تم قياس الأداء الانقباضي والانبساطي للبطين الايسر.

النتائج: أظهر مؤشر الكروية ارتباط عكسي معنوي مع عوامل القلب الانقباضية, ($0.05 > P$). أظهر مؤشر المخروطية علاقة عكسية غير معنوية مع عوامل القلب الانقباضية, ($0.05 < P$).

فيما يتعلق بدراسة ارتباط مؤشرات المخروطية والكروية مع عوامل القلب الانبساطية, اظهرت علاقة طردية غير معنوية ($0.05 < P$), فقط ارتباط طردي معنوي لمؤشر الكروية مع مؤشر حجم الاذين الايسر ($0.05 > P$).

الاستنتاجات: نستنتج أن مؤشرات البطين الايسر المحددة بتخطيط صدى القلب هي مقياس مباشر لإعادة تشكيل البطين الايسر إما مناطقيا بواسطة مؤشر المخروطية أو شاملا بواسطة مؤشر الكروية كما يمكنها أن تعكس الوظائف الانقباضية والانبساطية للبطين الايسر.

الكلمات المفتاحية: مؤشر الكروية, مؤشر المخروطية, احتشاء عضلة القلب الامامي.