Med. J. Cairo Univ., Vol. 93, No. 2, Accepted 20/4/2025
DOI: 10.22608/MJCU. 825-830, June 2025
www.medicaljournalofcairouniversity.net

Correlation of Angiographic SYNTAX Score to Left Ventricular Global Longitudinal and Circumferential Strain

ISLAM BASTAWY, M.D.; AHMED ONSY, M.D.; MARIAN HELMY, M.Sc. and YASMIN ABDELRAZEK, M.D.

The Department of Cardiology, Faculty of Medicine, Ain Shams University

Abstract

Background: Chronic myocardial ischemia results in left ventricular (LV) systolic dysfunction. The anatomical complexity of coronary artery disease (CAD) could be evaluated by the SYNTAX score.

Aim of Study: This study aimed to correlate the SYNTAX score in patients undergoing elective coronary angiography to the LV global longitudinal strain (GLS) and global circumferential strain (GCS) performed at rest by speckle-tracking echocardiography.

Patients and Methods: This study included 60 patients scheduled for elective invasive coronary angiography after being diagnosed with CAD by a positive non-invasive test for myocardial ischemia. Speckle- tracking echocardiography was used to measure LV GLS and GCS. SYNTAX score I was used to evaluate the anatomical complexity of CAD after angiography.

Results: Patients were divided into three groups based on the results of the coronary angiogram: Normal coronary angiogram (n=12), low SYNTAX score (n=28, <22), and high SYNTAX score (n=20, ≥22). Baseline characteristics were comparable between the three groups. The high SYNTAX score group showed worse LV GLS and GCS (–16.90±2.17% and –19.70±1.59 respectively) in comparison to low SYNTAX score (–19.36±2.21, p<0.001 and –22.11±2.02, p<0.001 respectively) and normal SYNTAX score (–20.33±2.06, p<0.001 and –22.17± 1.90, p<0.001). There was a significant inverse correlation of SYNTAX score to LV GLS and LV GCS (r=0.458, p=0.0002, r=0.411, p=0.0011) respectively.

Conclusion: LV GLS and LV GCS decline with the increase in CAD anatomical complexity measured by angiographic SYNTAX score.

Key Words: Angiographic SYNTAX score – GCS.

Correspondence to: Dr. Islam Bastawy,
E-Mail: islambastawy@hotmail.com

Introduction

THE Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) score is a coronary angiographic score that grades the anatomical complexity of the coronary arteries **[1]**. It has an important prognostic value related to long-term cardiovascular outcomes **[2]**. Also, it guides the choice of the revascularization strategy between either percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) in the presence of left main coronary artery disease (CAD) and/or multi-vessel disease after heart team discussions. In the presence of a low SYNTAX score (0-22), PCI is considered an accepted revascularization mode, while, an intermediate to high SYNTAX score (>22) favors CABG especially, in diabetic patients **[3]**.

Chronic myocardial ischemia results in left ventricular (LV) systolic dysfunction **[4]** that could be identified using myocardial strain imaging which has a higher sensitivity in detecting subtle myocardial dysfunction compared to LV ejection fraction (EF) **[5]**. The ischemic LV dysfunction detected by myocardial strain imaging correlates with coronary artery severity in invasive coronary angiography **[6]**.

This study aimed to correlate LV systolic function as assessed by speckle tracking peak systolic global longitudinal strain (GLS) with global circumferential strain (GCS), and anatomical complexity of coronary arteries as assessed by angiographic SYNTAX score in patients undergoing elective coronary angiography.

Patients and Methods

This study included 60 patients scheduled for elective invasive coronary angiography in Ain Shams University Hospitals from March 2020 to

December 2020 after being diagnosed with CAD by a positive non-invasive test for myocardial ischemia. All patients signed an informed written consent, and the research ethics committee of the Faculty of Medicine, at Ain Shams University, approved the study protocol (FMASU MS 203/2020). The study excluded patients with significant valve diseases, LV hypertrophy, previous myocardial infarction, CABG, PCI, resting wall motion abnormality in echocardiography, poor echogenicity, and irregular heart rhythm.

All patients were subjected to history taking and clinical examination to identify risk factors for CAD or established CAD. A transthoracic echocardiography study was done on all patients with left lateral decubitus using a General Electric (GE) Vingmed Ultrasound Vivid 7 system. A full 2- dimensional (D), motion (M)-mode, and Doppler echocardiographic examination was done for all patients in standard precordial apical (2-, 3- and 4-chamber images) and parasternal (short- axis images) views. The following measurements were obtained: LV EF fraction calculated using M-Mode, 2D eye-balling, and Simpson method, wall motion abnormality: using 2D echocardiography in apical and parasternal views, peak systolic GLS, and GCS using speckle tracking. With stable electrocardiogram (ECG) and breath holding, ECG-gated loops for later offline analysis were recorded. Loops of at least three ECG-gated entire cardiac cycles of the LV from apical 4,3 and 2 chamber views for the GLS and short axis at the basal, mid, and apical levels of the heart for the GCS, were recorded in the cine loop format. The recorded data was stored and later analyzed with the offline workstation software EchoPAC Dimension [12.0, GE Medical Systems GmbH, Germany]. The strain values for all the segments were recorded and averaged to obtain the GLS and GCS. A topographic representation of the regional and GLS of all 17 analyzed segments (Bull's eye configuration) was automatically generated. The normal value of GLS is –19.7±3% while the normal value of GCS is –23±3% **[7].**

Using multiple views, selective left and right coronary angiography was done to visualize coronary anatomy without foreshortening or side branch overlaps. The lesions of interest were defined as causing >-50% luminal obstruction in a vessel >-1.5mm in diameter. All images were evaluated by an experienced operator who was blinded to the results of strain echocardiography. After calculating the individualized score for each relevant lesion, the SYNTAX score was derived from their summation. Then after, the patients were divided into three groups based on the presence and/or the severity of CAD: no CAD on angiogram (zero SYNTAX score), low SYNTAX score (<22), and high SYNTAX score (>-22) **[3].**

Statistical analysis:

After collection and revision of data, Statistical Package for Social Science (IBM SPSS) (version 23) was used to enter data in. Mean and standard deviation represented quantitative data with parametric distribution. Numbers and percentages represented qualitative variables. We used Chi-square test to compare between qualitative data of the study groups. The comparison between more than two independent groups with quantitative data and parametric distribution was done by using the One Way ANOVA test. Post-hoc Spearman correlation coefficients were used to assess the correlation between two quantitative parameters in the same group. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the *p*-value was considered significant <0.05.

Results

Based on the coronary angiographic results, the study population was divided into three groups. Twelve patients (20%) had normal epicardial coronary arteries with zero SYNTAX score, while 48 patients (80%) had atherosclerotic epicardial coronary arteries with low SYNTAX score in 28 patients (46.7%) and high SYNTAX score in 20 patients (33.3%).

On comparing the baseline characteristics between the three groups, there was no statistically significant difference (Table 1). The comparison of echocardiographic assessments of LV systolic function showed no statistically significant difference in LV EF. While comparing LV GLS, the high SYNTAX score group showed significantly lower GLS than the low SYNTAX group (–16.90±2.17 versus –19.36±2.21, $p<0.001$) and zero SYNTAX score (–16.90±2.17 versus –20.33±2.06, $p<0.001$). Also on comparing LV GCS, the high SYNTAX score group showed significantly lower GCS than the low SYNTAX group (–19.70 ± 1.59 versus –22.11±2.02, $p<0.001$) and zero SYNTAX score (–19.70±1.59 versus –22.17±1.90, $p<0.001$) (Table 2).

There was a statistically significant weak inverse correlation between the peak systolic GLS and SYNTAX score values (r=–0.458, $p<0.001$) (Fig. 1). Also, there was a statistically significant weak inverse correlation between peak systolic GCS and SYNTAX score values (r=–0.411, $p<0.01$) (Fig. 2).

Table (1): Comparison of baseline characteristics between the study population sub-groups.

	Zero SYNTAX score N=12	Low SYNTAX score N=28	High SYNTAX score N=20	*p*-value
Age (years): Mean ± SD	53.92±12.48	60.07±7.77	53.75±10.01	0.05
Males: N (%)	9 (75.0%)	20 (71.4%)	14 (70.0%)	0.09
Smoking: N (%)	4 (33.3%)	16 (57.1%)	13 (65.0%)	0.21
Diabetes mellitus: N (%)	4 (33.3%)	13 (46.4%)	8 (40%)	0.73
Hypertension: N (%)	6 (50%)	13 (46.4%)	8 (40%)	0.84

SD: Standard deviation.

Table (2): Comparison of echocardiographic parameters between the study population sub-groups.

	Zero SYNTAX score N=12	Low SYNTAX score N=28	High SYNTAX score N=20	*p*-value	p_1	p_2	p_3
Ejection fraction: Mean ± SD	62.25±4.75	61.18±3.95	63.05±4.66	0.34			
GLS: Mean ± SD	-20.33±2.06	-19.36±2.21	-16.90±2.17	<0.001	0.2	<0.001	<0.001
Impaired GLS: N (%)	3 (25.0%)	11 (39.3%)	18 (90.0%)	<0.001			
Apical 2 longitudinal strain: Mean ± SD	-20.42±1.88	-19.54±2.67	-16.25±4.12	0.01	0.41	0.001	0.001
Apical 3 longitudinal strain: Mean ± SD	-20.42±2.68	-20.43±3.01	-17.80±3.25	<0.001	0.99	0.02	0.004
Apical 4 longitudinal strain: Mean ± SD	-20.50±3.34	-18.82±3.43	-17.70±3.53	0.09			
GCS: Mean ± SD	-22.17±1.90	-22.11±2.02	-19.70±1.59	<0.001	0.93	<0.001	<0.001
Impaired GCS: N (%)	6 (50.0%)	12 (42.9%)	18 (90.0%)	0.003			
Short axis basal circumferential strain: Mean ± SD	-22.00±2.22	-21.82±2.13	-19.80±1.99	0.003	0.806	0.006	0.002
Short axis mid circumferential strain: Mean ± SD	-22.33±1.87	-22.07±2.07	-20.05±1.73	0.001	0.69	0.002	0.001
Short axis apical circumferential strain: Mean ± SD	-22.00±1.54	-22.00±2.58	-20.05±1.82	0.007	1	0.017	0.003

GCS: Global circumferential strain. GLS: Global longitudinal strain. SD: Standard deviation.

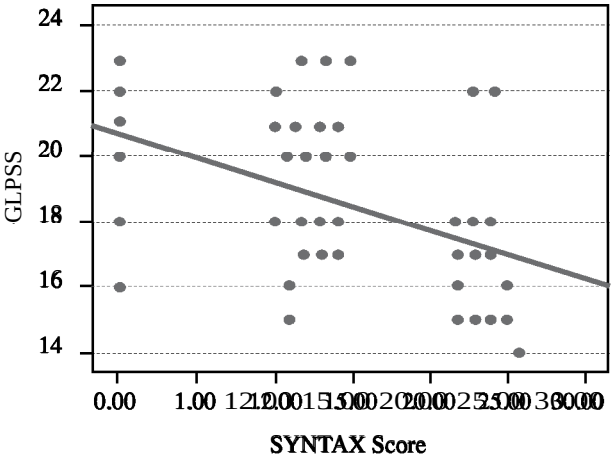

Fig. (1): Correlation between SYNTAX score and GLS.

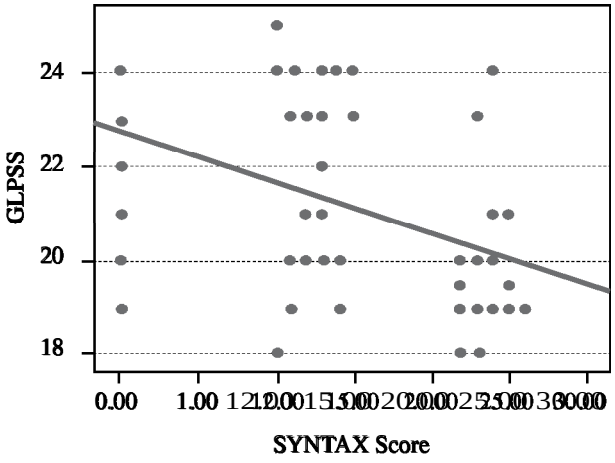

Fig. (2): Correlation between SYNTAX score and GCS.

Discussion

The main result of the current study is that despite normal LV EF of the study population and the absence of regional wall motion abnormality in resting echocardiography, there was a progressive decline in LV GLS and GCS with increasing the anatomical complexity of the coronary arteries as represented by the SYNTAX score. Although LV GLS is much more studied in the literature, both LV GLS representing longitudinal fiber shortening and LV GCS representing circumferential fiber shortening contribute to LV systolic function **[8].**

Our study was concordant with Vrettos's and colleagues study in 2016 **[9]** that was the first to correlate SYNTAX score and LV GLS in patients with stable angina with normal global and/or regional wall motion. They found a significant inverse correlation between LV GLS and SYNTAX score values (r=0.3869, p<0.001). Also, it was concordant with Biswas and colleagues study in 2020 **[10]** that was conducted on 117 patients with stable angina and it found a significant correlation between LV GLS and SYNTAX score (r=0.686, p<.0001). The relationship between LV GLS and coronary anatomical complexity could be translated into a relationship between LV GLS and significant myocardial ischemia as in Elamragy and colleagues in 2020 **[11]** who evaluated 101 patients by LV GLS and stress echocardiography followed by coronary angiography within 1 month and concluded stress echocardiography derived GLS increased the sensitivity to detect myocardial ischemia in intermediate pretest probability patients.

The SYNTAX score gives a score for coronary lesions in a coronary artery that is ›_1.5mm in diameter when it shows a coronary stenosis that involves ›_50% of the vessel diameter. The score of each lesion depends on some anatomical factors that reflect the severity of CAD like the proximity of the lesion in the coronary artery, the dominance of the coronary circulation, the presence of the lesion in a bi- or trifurcation, the length of the lesion, the presence of tortuosity, heavy calcification, total occlusion or thrombosis **[1]**. The Syntax score increases with the increase in the number of coronary lesions and their anatomical complexity. This may explain the inverse relationship of the SYNTAX score in our study with LV GLS and LV GCS. The presence of significant myocardial ischemia is associated with abnormal myocardial deformation that results in a subtle LV systolic dysfunction even in the absence of a significant decline in LV EF **[12,13]**. The presence of a normal LV EF does not exclude the presence of a significant coronary artery disease.

The SYNTAX score has a well-established prognostic value in the prediction of major adverse cardiac events, and it is essential in guiding the coronary revascularization **[1-2,14]**. However, the relation between the SYNTAX score and LV systolic function is not well established. Also, most studies that focused on the relationship between speckle-tracking echocardiography and the anatomical complexity of CAD focused on the LV GLS **[9,15]**. Our study added that in addition to the worsening of LV GLS with increasing the SYNTAX score, also the LV GCS showed a similar decline. The complex array of myocardial architecture is formed mainly of longitudinal subendocardial fibers which are more susceptible to myocardial ischemia than subepicardial circumferential fibers. In the current study, GCS also showed an inverse correlation with increasing SYNTAX score which suggests that the effect of CAD extends to the sub-epicardial fibers **[5].**

The results of this study highlighted the value of adding LV GLS and GCS to the evaluation of patients with suspected myocardial ischemia and normal EF which could improve the pretest probability of myocardial ischemia and predict the anatomical complexity of the coronary anatomy.

Limitations:

One of the limitations of this study is its small number of patients. Also, LV deformation is affected by variable hemodynamic and structural factors that resulted in the exclusion of many patients from the study. Moreover, the normal values for circumferential strain are still not well established.

Conclusions:

There was a progressive decline in LV GLS and LV GCS with increasing SYNTAX score in patients with suspected myocardial ischemia and normal LV EF in the absence of resting wall motion abnormality. High SYNTAX score group showed worse LV GLS and LV GCS in comparison to low SYNTAX score and normal SYNTAX score.

References

1- SIANOS G., MOREL M.A., KAPPETEIN A.P., MORICE M.C., COLOMBO A., DAWKINS K., VAN DEN BRAND M., VAN DYCK N., RUSSELL M.E., MOHR F.W. and SERRUYS P.W.: The SYNTAX Score: An angiographic tool grading the complexity of coronary artery disease. EuroIntervention, Aug. 1 (2): 219-27, 2005.

2- WYKRZYKOWSKA J.J., GARG S., GIRASIS C., DE VRIES T., MOREL MA, VAN ES G.A., BUSZMAN P., LINKE A., ISCHINGER T., KLAUSS V., CORTI R., EBERLI F., WIJNS W., MORICE M.C., DI MARIO C., VAN GEUNS R.J., JUNI P., WINDECKER S. and SERRUYS P.W.: Value of the SYNTAX score for risk assessment in the all-comers population of the randomized multicenter LEADERS (Limus Eluted from A Durable versus ERodable Stent coating) trial. J. Am. Coll. Cardiol., 56: 272–27, 2010.

3- NEUMANN F.J., SOUSA-UVA M., AHLSSON A., ALFONSO F., BANNING A.P., BENEDETTO U., BYRNE RA, COLLET J.P., FALK V., HEAD S.J., JÜNI P., KASTRATI A., KOLLER A., KRISTENSEN S.D., NIEBAUER J., RICHTER D.J., SEFEROVIC PM, SIBBING D, STEFANINI G.G., WINDECKER S., YADAV R. and ZEMBALA M.O.: ESC Scientific Document Group. 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur Heart J., Jan 7; 40 (2): 87-165, 2019. doi: 10.1093/eurheartj/ehy394. Erratum in: Eur Heart J. 2019 Oct 1;40(37):3096.

4- SHAO C, WANG J, TIAN J. and TANG Y.D.: Coronary Artery Disease: From Mechanism to Clinical Practice. Adv. Exp. Med. Biol., 1177: 1-36, 2020. doi: 10.1007/978-981-15-2517-9_1.

5- SMISETH O.A., TORP H., OPDAHL A., HAUGAA K.H. and URHEIM S.: Myocardial strain imaging: How useful is it in clinical decision making? Eur. Heart J., Apr. 14; 37 (15): 1196-207, 2016. doi: 10.1093/eurheartj/ehv529.

6- BIERING-SØRENSEN T., HOFFMANN S., MOGELVANG R., ZEEBERG IVERSEN A., GALATIUS S., FRITZ- HANSEN T., BECH J. and JENSEN J.S.: Myocardial strain analysis by 2-dimensional speckle tracking echocardiography improves diagnostics of coronary artery stenosis in stable angina pectoris. Circ. Cardiovasc. Imaging, Jan. 7 (1): 58-65, 2014. doi: 10.1161/CIRCIMAGING.113.000989.

7- YINGCHONCHAROEN T., AGARWAL S., POPOVIĆ Z.B. and MARWICK T.H.: Normal ranges of left ventricular strain: A meta-analysis. J. Am. Soc. Echocardiogr., Feb. 26 (2): 185-91, 2013. doi: 10.1016/j.echo.2012.10.008.

8- CARLSSON M., HEIBERG E., OSTENFELD E., STEDING-EHRENBORG K., KOVÁCS S.J., FLACHSKAMPF F. and ARHEDEN H.: Functional Contribution of Circumferential Versus Longitudinal Strain: Different Concepts Suggest Conflicting Results. Journal of the American College of Cardiology, 71 (2): 254–255, 2018. https://doi.org/10.1016/j.jacc.2017.09.1156.

9- VRETTOS A., DAWSON D., GRIGORATOS C. and NIHOYANNOPOULOS P.: Correlation between global longitudinal peak systolic strain and coronary artery disease severity as assessed by the angiographically derived SYNTAX score. Echo research and practice, 3 (2): 29–34, 2016. https://doi.org/10.1530/ERP-16-0005.

10- BISWAS K., MUKHERJEE A., NANDI S., KHANRA D., SHARMA R.K. and MAJI S.: Utility of global longitudinal strain to detect significant coronary artery disease, its extent and severity in patients with stable ischemic heart disease. Echocardiography (Mount Kisco, N.Y.), 37 (12): 2000–2009, 2020. https://doi.org/10.1111/echo.14908.

11- ELAMRAGY A.A., ABDELWAHAB M.A., ELREMISY D.R., HASSAN M., AMMAR W.A. and TAHA H.S.: Additional diagnostic accuracy of global longitudinal strain at peak dobutamine stress in patients with moderate pretest probability of coronary artery disease. Echocardiography (Mount Kisco, N.Y.), 37 (8): 1222–1232, 2020. https://doi.org/10.1111/echo.14803.

12- UÇAR H., GÜR M., BÖREKÇI A., YıLDıRıM A., BAYKAN A.O., YÜKSEL KALKAN G., KOÇ M., ŞEKER T., COŞKUN M., ŞEN Ö. and ÇAYLı M.: Relationship between extent and complexity of coronary artery disease and different left ventricular geometric patterns in patients with coronary artery disease and hypertension. Anatolian journal of cardiology, 15 (10): 789–794, 2015. https://doi.org/10.5152/akd.2014.5747.

13- MONTGOMERY D.E., PUTHUMANA J.J., FOX J.M. and OGUNYANKIN K.O.: Global longitudinal strain aids the detection of non-obstructive coronary artery disease in the resting echocardiogram. European heart journal. Cardiovascular Imaging, 13 (7): 579–587, 2012. https://doi.org/10.1093/ejechocard/jer282.

14- YANES BOWDEN G.J., BOSA OJEDA F., JIMÉNEZ SOSA A., SÁNCHEZ-GRANDE FLECHA A., MÉNDEZ VARGAS C., LEIVA GORDILLO M. and MIRANDA BACALLADO J.: Prognostic value of SYNTAX score and SYNTAX score II in an 'all-comers' population treated with angoplasty. Coronary artery disease, 32 (3): 231–240, 2021. https://doi.org/10.1097/MCA.0000000000000956.

15- ABDELRAZEK G., YASSIN A. and ELKHASHAB K.: Correlation between global longitudinal strain and SYNTAX score in coronary artery disease evaluation. Egypt Heart J., May 15; 72 (1): 22, 2020. doi: 10.1186/s43044-020-00064-2.

علاقة مقياس SYNTAX فى قسطرة الشرايين التاجية بالإجهاد الطولى والمحيطى الشامل للبطين الأيسر

المقدمة: يؤدى نقص تروية عضلة القلب المزمن إلى خلل انقباضى فى البطين الأيسر. يمكن تقييم التعقيد التشريحى لمرض الشريان لدى المرضى الذين يخضعون SYNTAX وهدفت هذه الدراسة إلى ربط مقياس SYNTAX التاجى باستخدام مقياس لقسطرة الشريان التاجى بالإجهاد الطولى الشامل للبطين الأيسر والإجهاد المحيطى الشامل باستخدام تخطيط صدى القلب بتتبع النقاط.

طرق الدراسة: شملت هذه الدراسة ٦٠ مريضًا مُقررًا لهم إجراء تصوير للشرايين التاجية الاختياري بعد تشخيص إصابتهم بمرض الشريان التاجى بناء على ايجابية لاختبار غير نافذ مشخص لنقص تروية عضلة القلب. استُخدم تخطيط صدى القلب بتتبع البقع من الدرجة الأولى SYNTAX لقياس الاجهاد الطولى الشامل والإجهاد المحيطى الشامل للبطين الأيسر واستُخدم مقياس لتقييم التعقيد التشريحى لمرض الشريان التاجى بعد تصوير الشرايين التاجية.

النتائج: تم تقسيم المرضى إلى ثلاث مجموعات بناءً على نتائج تصوير الشرايين التاجية: تصوير الأوعية التاجية الطبيعى (١٢)، مقياس SYNTAX منخفض (28, ‹22)، ومقياس SYNTAX عالة (20, ≥22). كانت الخصائص الأساسية قابلة للمقارنة بين المجموعات الثلاث. أظهرت المجموعة ذات الدرجات العالية فى مقياس SYNTAX انخفاضاً فى نوعى الإجهاد الطولى والمحيطى (–16,90 ± 2,17%, –19,70 ± 1,59% على التوالى) مقارنة بالدرجات المنخفضة فى مقياس SYNTAX (-19.36 ± 2.21, p <0.001 على التوالى) والدرجات الطبيعية فى مقياس SYNTAX (-20.33 ± 2.06, p <0.001, -22.17 ± 1.90, p <0.001). وكان هناك ارتباط عكسى كبير بين درجة SYNTAX والاجهاد الطولى و (r=0,458, p=0,0002 ، والاجهاد المحيطى r=0,411, p=0,0011) على التوالى.

الخلاصة: ينخفض مستوى الاجهاد الطولى في البطين الأيسر والاجهاد المحيطى فى البطين الأيسر مع زيادة التعقيد التشريحى فى مرضى قصور الشرايين التاجية والذي يتم قياسه بواسطة مقياس SYNTAX فى تصوير االشرايين التاجية.