INTERNATIONAL JOURNAL OF MEDICAL ARTS

Volume 5, Issue 12, December 2023

https://ijma.journals.ekb.eg/

Print ISSN: 2636-4174

Online ISSN: 2682-3780

Available online at Journal Website
https://ijma.journals.ekb.eg/
Main Subject [Cardiology]

Original Article

Assessment of Left Ventricular Systolic Function by Three-Dimensional Echocardiography Pre and Post Aortic Valve Replacement in Patient with Severe Aortic Stenosis

Elsayed M. Elsemelawy *[1], Taher S. Abd El-kareem [1, 2], Mohye Eldin El-Abbady [1], Mohammad I. Al-Deftar [1]

[1] Department of Cardiology, Faculty of Medicine, Al-Azhar University, Cairo, Egypt
[2] Department of Cardiology, Nizwa Hospital, Nizwa, Oman

Article information

Received: 28-07-2023

Accepted: 29-12-2023

DOI: 10.21608/IJMA.2023.225666.1748.

*Corresponding author

Email: elsayedabdelhady29@gmail.com

Citation: Elsemelawy EM, Abd El-kareem TS, El-Abbady M, Al-Deftar MI. Assessment of Left Ventricular Systolic Function by Three-Dimensional Echocardiography Pre and Post Aortic Valve Replacement in Patient with Severe Aortic Stenosis. IJMA 2023 December; 5 [12]: 3943-3949. doi: 10.21608/IJMA.2023.225666.1748.

ABSTRACT

Background: Despite left ventricle [LV] dysfunction, the aortic valve replacement risk for aortic stenosis [AS] was acceptable and related mainly to coronary artery disease and mean aortic gradient. The long-term survival was related to cardiac output and coronary disease.

The Aim of the work: To assess the potential role of three-dimensional [3D] speckle tracking echocardiography [STE] in the detection of systolic dysfunction of the LV in severe aortic stenosis pre- and post- valve replacement.

Patients and Methods: Forty patients with severe AS in the pre- and post-surgical valve replacement were enrolled and assigned as group A. Group [B] included [20] sex-and age-matched apparently healthy individuals as a control group.

Results: There was a statistically significant differences between groups on the 2D and 3D STE but the 2D STE was the most significant as regard the global longitudinal strain. After aortic valve replacement, basic echocardiographic parameters showed no significant differences after than before aortic valve replacement. However, there was a significant improvement of global longitudinal strain and global circumferential strain after than before surgery by 2D and 3D speckle tracking echocardiography.

Conclusion: The speckle tracking echocardiography 2D or 3D is an optional significant modality for detection of subclinical left ventricular dysfunction in patients with severe aortic stenosis and preserved EF.

Keywords: Echocardiography; Aortic Valve; Stenosis; Speckle Tracking; Three-dimensional.

INTRODUCTION

Due to long-term pressure overload of the left ventricle [LV], patients with severe aortic stenosis [AS] develop LV enlargement and dysfunction [1]. Patients with severe aortic stenosis or regurgitation may develop permanent myocardial dysfunction [e.g., LV heart failure], which increases the risk of sudden death. Aortic valve replacement [AVR] is an effective procedure that may minimize the risk of sudden death and improving LV cardiac function [2].

Standard interventional techniques [e.g., cardiac catheterization and routine echocardiography], may underestimate the LV dysfunction, especially in patients with maintained ejection fraction [EF]. This hidden LV dysfunction in aortic stenosis/aortic regurgitation [AS/AR] has serious morbid and fatal consequences [3].

Many recent investigations have shown that global myocardial strain has prognostic relevance. This may aid in better estimating the prognosis of such individuals by identifying mild LV dysfunction. In untreated patients, LV strain performance deteriorates over time, therefore recognizing mild myocardial failure at an early stage may have therapeutic significance [4]. Due to inherent foreshortening inaccuracies and reliance on geometric models, two-dimensional [2D] echocardiography has limits in estimating LV volumes, ejection percentage, and LV mechanics [5].

Three-dimensional [3D] speckle tracking echocardiography [STE] is an innovative method for the quantification of the cardiac deformation. STE is based on the monitoring of ultrasonic speckles in gray scale full-volume 3D pictures. Advances in ultrasound technologies have made 3D speckle tracking widely available [6]. With the advancement of 3D echocardiography, repeatability and accuracy have improved. Data on the feasibility, accuracy, and clinical uses of 3D STE are fast becoming available. 3D STE derives numerous metrics from the tracking findings, including longitudinal, circumferential, and radial strains, as well as a combined assessment of longitudinal and circumferential strains, known as area strain [7].

LV rotational movements such as rotation, twist, and torsion can also be quantified using 3D STE. It gives more information about global and localized cardiac deformation. The diagnosis of subclinical myocardial involvement in HF, arterial hypertension, dyssynchrony, and ischemic heart disease are the main uses [8].

The current work aimed to assess the role of 3D STE in the recognition of systolic dysfunction of the LV in severe aortic stenosis pre- and post- valve replacement.

PATIENTS AND METHODS

The present study included [40] patients [Group A] with severe aortic stenosis due to congenital, rheumatic or sclero-calcific aortic valve disease and [20] age- and sex-matched healthy individuals as a control group [Group B]. Echocardiography was performed at the Islamic center, Al-Azhar University, Cairo, Egypt.

We included patients with severe aortic stenosis pre- and post-surgical valve replacement. However, we excluded patient with other congenital heart diseases, significant mitral regurgitation and stenosis, previous cardiac surgical or percutaneous intervention, patients with conduction abnormalities, pacemaker, ongoing arrhythmia, documented ischemic heart diseases [IHD], poor echocardiographic window and patient refusal.

All patients with severe AS were subject to carful history taking, clinical examination [general and local cardiac examination] in a systematic manner. A resting standard 12-leads surface electrocardiogram was performed**.** Then, 2 D and 4 D echocardiography was performed as described elsewhere [9, 10].

Briefly, the standard echo-Doppler was performed using a 2.5 multifrequency 1.7- 4 MHz transducer [GE Vivid 95 Ultrasound Machine, GE HealthCare, USA] in the left lateral decubitus position. Images were registered in the standard views. Then, calculations were completed according to the American Society of Echocardiography recommendations. The B-mode assessed wall motion, valves, pericardial sac or any congenital heart diseases. The M-mode assessed left atrial and aortic root dimensions, and LV measurements [end diastolic diameter [LVEDd], left ventricular end systolic diameter [LVESd], Interventricular septum thickness [IVSd], and posterior wall thickness [LVPWT]], LV systolic function [ejection fraction and fractional shortening] and relative wall thickness. After that, a doppler study was performed for evaluation of the inflow at the mitral valve was recorded for the assessment of E/A ratio and evaluation of the left ventricular diastolic function, and any valve diseases. Finally, transmitral doppler inflow and tissue pulsed wave doppler was performed to estimate the peak of early diastole relaxation velocity [Em] of the septal mitral annulus and the ratio of the transmitral peak early velocity [E] to Em [E/Em ratio] was calculated.

The 4-D volumetric transducer was used to acquire a full volume scan by harmonic imaging from an apical approach, using a frame rate higher than 40% of the heart rate to increase recognition of the "speckles" in successive frames. Data sets were stored digitally in raw data format and equipped with commercially available software [4D Auto LVQ software], for analysis of LV volumes, EF, LV mass, and 4D STE deformation parameters. By the reported approach, LV end-diastolic [EDV, mL] and LV end- systolic volume [ESV, mL] were calculated, and EF% = [EDV-ESV]/EDV x 100 and other measures were derived. All patients were assessed three months post-intervention.

Data analysis: The collected data was anonymized, fed to statistical package of social sciences [SPSS] package, version 25 [IBM Corp, Armonk, NY, USA]. Quantitative normally distributed data were presented by the arithmetic mean ±SD [Standard deviation], while categorical data were presented by relative frequency and percentages [calculated from each group]. Comparison between the study and control groups was performed by independent samples "t" and Chi square tests according to type of data. P value < 0.05 was considered statistically significant.

RESULTS

In the study group, 52.5% were NYHA grade I, while 20.0%, 15.0% and 12.5% were grades II, III and IV, respectively. Thus, NYHA class I was the most common among study subjects. The age, sex, BMI, and other medical history of the two groups did not show any significant difference [table 1].

There was no statistically significant difference in the basic echocardiographic parameters taken before and after aortic valve replacement [table 2].

Table [3] demonstrates a statistically significant presence of left ventricular subclinical dysfunction within the aortic stenosis group, specifically in relation to global longitudinal strain and global circumferential strain. This was observed through the use of 2D and 3D speckle tracking echocardiography before the aortic valve replacement.

Table [4] presents statistically significant findings for both 2D speckle tracking echocardiography [STE] and 3D STE, with 2D STE showing greater significance in terms of global longitudinal strain. Similarly, 2D STE exhibits higher significance than 3D STE regarding global circumferential strain.

Table [5] reveals that there is no statistically significant difference in basic echocardiographic parameters when comparing measurements before and after aortic valve replacement.

According to Table [6], there was a notable enhancement in global longitudinal strain and global circumferential strain observed through both 2D and 3D speckle tracking echocardiography following aortic valve replacement.

Table [1]: Patient personal and clinical characteristics among study groups

Variables			Study group	Control group	Test	P
Demographic data	Age [years]		75.15 ± 6.60	73.30 ± 3.56	1.169	0.247
	BMI [kg/m^2]		29.99 ± 18.12	27.60 ± 3.63	0.583	0.562
	BSA [m^2]		1.99 ± 0.17	2.01 ± 0.11	0.485	0.629
	Sex [n, %]	Male	27 [67.5%]	13 [65%]	0.038	0.846
		Female	13 [32.5%]	7 [35%]		
	Residence [n%]	Urban	21 [52.5%]	6 [30%]	2.727	0.099
		Rural	19 [47.5%]	14 [70%]		
Medical history	Hypertension		18 [45%]	7 [35%]	0.549	0.459
	Diabetes mellitus		14 [35%]	7 [35%]	0.001	1.0
	Hepatitis		21 [52.5%]	11 [55%]	0.033	0.855
	Dyslipidemia		24 [60%]	8 [40%]	2.143	0.148
	Chronic kidney disease		18 [45%]	8 [40%]	0.136	0.713
	COPD		12 [30.0%]	5[25.0%]	0.164	0.664
	Smoking		8 [20%]	5 [25%]	0.196	0.658
Blood pressure [mmHg]	Systolic		136.25 ± 12.70	135.25 ± 16.26	0.261	0.795
	Diastolic		84.25 ± 6.46	85.50 ± 9.45	0.603	0.549

Table [2]: Comparison of the echocardiographic parameters in the two study groups

	Groups		Test	P value
	Cases group [n= 40]	Control group [n= 20]		
Resting heart rate [beats/min]	76.10 ± 12.50	77.35 ± 12.45	0.366	0.719
P-wave duration [ms]	106.75 ± 7.64	110 ± 6.73	t1.615	0.112
PR interval [ms]	114.33 ± 10.82	112.55 ± 6.99	0.666	0.508
QRS duration [ms]	91.38 ± 7.79	93.35 ± 14.51	0.688	0.494
QT mean interval [ms]	409.78 ± 36.42	412.70 ± 11.56	0.349	0.728
LA d	37.63 ± 6.27	36.05 ± 5.18	0.969	0.337
LAV	39.48 ± 9.30	36.25 ± 8.10	1.319	0.192
LAVI	21.02 ± 4.96	18.21 ± 4.63	2.116	**0.039***
IVS	1.45 ± 0.21	1.32 ± 0.17	2.442	**0.018***
PWT	1.28 ± 0.17	1.17 ± 0.14	2.692	**0.009***
EDD	5.47 ± 0.44	5.39 ± 0.66	0.579	0.565
ESD	3.93 ± 0.62	3.79 ± 0.84	0.757	0.452
EDV	148.23 ± 28.31	145.35 ± 40.55	0.321	0.749
EDVI	79.12 ± 15.97	72.70 ± 21.50	1.303	0.198
ESV	71.04 ± 27.02	67.27 ± 36.26	0.454	0.651
ESVI	37.71 ± 14.03	33.86 ± 19.27	0.881	0.382
LVM	339.94 ± 81.04	285.42 ± 91.43	2.354	**0.022***
LVMI	181.70 ± 46.36	143.32 ± 48.84	2.970	**0.004***
EF	58.70 ± 3.08	61 ± 1.92	3.048	**0.003***
E	93.65 ± 9.57	90.50 ± 10.64	1.158	0.252
A	90.48 ± 15.03	82.35 ± 15.61	1.949	0.056
E/A ratio	1.08 ± 0.32	1.15 ± 0.33	0.785	0.436

Table [3]: Comparison of the echocardiographic parameters in the two study groups

	Groups		Test	P
	Cases group [n= 40]	Control group [n= 20]		
2D GLS	-12.33 ± 2.07	-16.60 ± 2.85	6.629	**< 0.001***
2D GCS	-12.65 ± 2.08	-15.35 ± 2.80	4.213	**< 0.001***
3D-GLS	-20.18 ± 1.92	-25.10 ± 1.71	7.726	**< 0.001***
3D-GCS	-21.05 ± 1.93	-23.50 ± 1.99	2.716	**0.009***

Table [4]: Predictive ability of 2D- and 3D GLS and GCS in differentiating cases with AS from control group

	2D-GLS	3D-GLS	2D-GCS	3D-GCS
AUC	0.894	0.765	0.928	0.698
95% CI of AUC	0.808 - 0.980	0.638 – 0.892	0.866 - 0.989	0.554 – 0.841
Cut off point	> -16	> -15	> -23	> -22
Sensitivity	80 %	72.5 %	87.5 %	62.5 %
Specificity	84 %	55 %	80 %	75 %
Accuracy	80 %	65 %	85 %	60 %
PPV	88 %	70 %	82 %	68 %
NPV	84 %	68 %	85 %	64 %
P	**< 0.001***	**0.002***	**< 0.001***	**0.013***

Table [5]: Comparison of the echocardiographic parameters in the cases group before and after valve replacement

	Study group		Test	P value
	Before replacement	After replacement		
LA d	37.63 ± 6.27	36.10 ± 5.20	1.117	0.371
LAV	39.48 ± 9.30	35.33 ± 7.65	**2.235**	**0.031***
LAVI	21.02 ± 4.96	17.70± 4.39	**3.365**	**0.002***
IVS	1.45 ± 0.21	1.36 ± 0.21	1.995	0.053
PWT	1.28 ± 0.17	1.44 ± 1.56	**2.148**	**0.042***
EDD	5.47 ± 0.44	5.35 ± 0.54	1.026	0.311
ESD	3.93 ± 0.62	3.71 ± 0.71	1.394	0.171
EDV	148.23 ± 28.31	141.91 ± 33.82	0.862	0.394
EDVI	79.12 ± 15.97	70.87 ± 18	**2.245**	**0.031***
ESV	71.04 ± 27.02	63.26 ± 30.85	1.148	0.258
ESVI	37.71 ± 14.03	31.74 ± 16.37	1.771	0.084
LVM	339.94 ± 81.04	287.90 ± 86.08	**2.676**	**0.011***
LVMI	181.70 ± 46.36	143.99 ± 44.74	**3.857**	**0.001***
EF	58.70 ± 3.08	60.83 ± 10.37	**2.541**	**0.035***
E	93.65 ± 9.57	90.63 ± 9.09	1.389	0.173
A	90.48 ± 15.03	82.38 ± 16.28	**2.338**	**0.025***
E/A ratio	1.08 ± 0.32	1.16 ± 0.33	1.073	0.290

Table [6]: Comparison of the echocardiographic parameters in the cases group before and after valve replacement

	Study group		Test	P
	Before replacement	After replacement		
GLS	-12.33 ± 2.07	-16.03 ± 2.02	7.29	**< 0.001***
GCS	-12.65 2.08	-15.60 ± 2.01	6.463	**< 0.001***
3D-GLS	-21.18 ±1.92	-24.58 ± 1.93	5.562	**< 0.001***
3D-GCS	-22.05 ± 1.93	-24.43 ± 8.23	1.983	0.054

DISCUSSION

In the current work, both study and control groups were comparable in terms of age, gender, hypertension, diabetes mellitus, and smoking, which was consistent with **Kaler *et al.*** [11]. We also discovered no significant difference in EF between the two groups. This was consistent with previous studies found 2D global strains to be improved after AVR in AS, even if LVEF did not alter much [12, 13]. Yet inconsistent results on the amount of LVEF improvement can be observed in other investigations [14-16].

GLS measurements in the current work after three months of aortic valve replacement were better than baseline readings. These results are in accordance with **Al-Rashid *et al.*** [17]. They reported that the GLS one week after TAVR was comparable to that at baseline [- 15,9 ± 4.3 vs -16.8 ± 4.1; p 0.14]. However, it was considerably improved three months later [-15.9 4.3% vs. 19.5 3.5%; p 0.001]. GLS improves three months after TAVR, although LV EF does not alter significantly, indicating an early recovery of LV longitudinal function after surgery.

Lozano Granero *et al.* [18] discovered a moderate but statistically significant improvement in GLS between baseline and discharge [GLS% 14.6 5.0 at baseline; 15.7 5.1 at discharge with AVR, p = 0.0116].

Kafa *et al.* [19] reported interesting findings in their study of patients with severe AS before and after AVR. All patients had retained EF. Despite the lengthier follow-up, GLS values improved significantly from pre-AVR [-14.8%] to post AVR [-17.2%]. Despite a preserved postoperative EF and obvious LV mass regression in patients with severe AS, about 20% of patients survived more than a year after aortic valve replacement had an abnormal LV-GLS value on postoperative echocardiography, emphasizing the importance of early intervention.

In addition, **Abdelshafey *et al.*** [20] evaluated 15 patients with AS and found that myocardial strain levels improved significantly. The GLS 15.3 before vs. 18.5 after, had a mean change of

2.1% [p value = 0.02], global circumferential strain [GCS 28.9 vs. 31.9] had a mean change of 2.9% [p = 0.036].

When their respective baseline levels were healthier, the amount of LV function recovery as determined by GLS and GCS on follow up was greater. This clearly reveals that worse LV function [GLS/GCS] at baseline is associated with poor LV recovery, indicating the need for early diagnosis of LV dysfunction by global longitudinal and circumferential strains to decide on the timing of aortic valve replacement. In contrast to LV ejection fraction, left ventricular end diastolic volume, or left ventricular end systolic volume, speckle tracking analysis detects modest LV function changes significantly earlier. Our findings support the idea of intervening early in aortic valve disease by including strain analysis in the evaluation of patients for aortic valve replacement. This is in accordance with previous studies with comparable results [21, 22].

Lancellotti *et al.* [23] showed that 2DGLS may distinguish between high- and low-risk patients for future cardiac events. **Yingchoncharoen *et al.*** [24] also revealed that 2DGLS has a substantial added benefit in predicting future cardiovascular events above other clinical and echocardiographic indicators.

However, this is in contrast to the findings of **Yasufumi *et al.*** [25] who evaluated 104 patients and discovered that 3DGLS is the most robust marker for predicting future adverse cardiac events in asymptomatic severe AS patients with intact LVEF.

In conclusion, speckle tracking echocardiography 2D or 3D is an optional significant modality for detection of subclinical left ventricular dysfunction in patients with severe aortic stenosis and preserved EF.

Financial and non-financial relations and activities of interest: None

REFERENCES

1. Tanaka H. Efficacy of echocardiography for differential diagnosis of left ventricular hypertrophy: special focus on speckle-tracking longitudinal strain. J Echocardiogr. 2021 Jun;19[2]:71-79. doi: 10.1007/s12574-020-00508-3.
2. Ajmone Marsan N, Delgado V, Shah DJ, Pellikka P, Bax JJ, Treibel T, Cavalcante JL. Valvular heart disease: shifting the focus to the myocardium. Eur Heart J. 2023 Jan 1;44[1]:28-40. doi: 10.1093/eurheartj/ehac504.
3. van de Bovenkamp AA, Enait V, de Man FS, Oosterveer FTP, Bogaard HJ, Vonk Noordegraaf A, van Rossum AC, Handoko ML. Validation of the 2016 ASE/EACVI Guideline for Diastolic Dysfunction in Patients with Unexplained Dyspnea and a Preserved Left Ventricular Ejection Fraction. J Am Heart Assoc. 2021 Sep 21;10[18]:e021165. doi: 10.1161/JAHA.121.021165.
4. Saijo Y, Isaza N, Conic JZ, Desai MY, Johnston D, Roselli EE, *et al.* Left Ventricular Longitudinal Strain in Characterization and Outcome Assessment of Mixed Aortic Valve Disease Phenotypes. JACC Cardiovasc Imaging. 2021 Jul;14[7]:1324-1334. doi: 10.1016/j.jcmg.2021.01.020.
5. Muraru D, Niero A, Rodriguez-Zanella H, Cherata D, Badano L. Three-dimensional speckle-tracking echocardiography: benefits and limitations of integrating myocardial mechanics with three-dimensional imaging. Cardiovasc Diagn Ther. 2018 Feb;8[1]:101-117. doi: 10.21037/cdt.2017.06.01.
6. Gao L, Lin Y, Ji M, Wu W, Li H, Qian M, *et al.* Clinical Utility of Three-Dimensional Speckle-Tracking Echocardiography in Heart Failure. J Clin Med. 2022 Oct 26;11[21]:6307. doi: 10.3390/jcm11216307.
7. Keller M, Heller T, Duerr MM, Schlensak C, Nowak-Machen M, Feng YS, Rosenberger P, Magunia H. Association of Three-Dimensional Mesh-Derived Right Ventricular Strain with Short-Term Outcomes in Patients Undergoing Cardiac Surgery. J Am Soc Echocardiogr. 2022 Apr;35[4]:408-418. doi: 10.1016/j.echo.2021.11.008.
8. Xu J, Yang W, Zhao S, Lu M. State-of-the-art myocardial strain by CMR feature tracking: clinical applications and future perspectives. Eur Radiol. 2022 Aug;32[8]:5424-5435. doi: 10.1007/s00330-022-08629-2.
9. Baldea SM, Velcea AE, Rimbas RC, Andronic A, Matei L, Calin SI, *et al.* 3-D Echocardiography Is Feasible and More Reproducible than 2-D Echocardiography for In-Training Echocardiographers in Follow-up of Patients with Heart Failure with Reduced Ejection Fraction. Ultrasound Med Biol. 2021 Mar;47[3]:499-510. doi: 10.1016/j.ultrasmedbio.2020.10.022.
10. Saraiva RM, Scolin EMB, Pacheco NP, Bouret ME, Mediano MFF, Holanda MT, Costa ARD. 3-Dimensional Echocardiography and 2-D Strain Analysis of Left Ventricular, Left Atrial and Right Ventricular Function in Healthy Brazilian Volunteers. Arq Bras Cardiol. 2019 Nov;113[5]:935-945. doi: 10.5935/abc.20190155.
11. Kaler GPS, Mahla R, Mahla H, Choudhary S, Singh G, Patel RP, Kaler NK. Speckle Tracking Echocardiographic Assessment of Left Ventricular

Function by Myocardial Strain Before and After Aortic Valve Replacement. J Saudi Heart Assoc. 2022 Jan 5;33[4]:353-363. doi: 10.37616/2212-5043.1288.

12. Carasso S, Cohen O, Mutlak D, Adler Z, Lessick J, Aronson D, *et al.* Relation of myocardial mechanics in severe aortic stenosis to left ventricular ejection fraction and response to aortic valve replacement. Am J Cardiol. 2011 Apr;107 [7]:1052-7. doi: 10.1016/j.amjcard.2010.11.032.

13. Delgado V, Tops LF, van Bommel RJ, van der Kley F, Marsan NA, Klautz RJ, *et al.* Strain analysis in patients with severe aortic stenosis and preserved left ventricular ejection fraction undergoing surgical valve replacement. Eur Heart J. 2009 Dec; 30[24]:3037-47. doi: 10.1093/eurheartj/ehp351.

14. Iwahashi N, Nakatani S, Kanzaki H, Hasegawa T, Abe H, Kitakaze M. Acute improvement in myocardial function assessed by myocardial strain and strain rate after aortic valve replacement for aortic stenosis. J Am Soc Echocardiogr. 2006 Oct; 19[10]:1238-44. doi: 10.1016/j.echo.2006.04.041.

15. Bauer F, Eltchaninoff H, Tron C, Lesault PF, Agatiello C, Nercolini D, Derumeaux G, Cribier A. Acute improvement in global and regional left ventricular systolic function after percutaneous heart valve implantation in patients with symptomatic aortic stenosis. Circulation. 2004 Sep 14;110(11):1473-6. doi: 10.1161/01.CIR.0000134-961.36773.D6.

16. Strotmann JM, Lengenfelder B, Blondelot J, Voelker W, Herrmann S, Ertl G, Weidemann F. Functional differences of left ventricular hypertrophy induced by either arterial hypertension or aortic valve stenosis. Am J Cardiol. 2008;101[10]:1493-7. doi: 10.1016/j.amjcard.2008.01.026.

17. Al-Rashid F, Totzeck M, Saur N, Jánosi RA, Lind A, Mahabadi AA, Rassaf T, Mincu RI. Global longitudinal strain is associated with better outcomes in transcatheter aortic valve replacement. BMC Cardiovasc Disord. 2020 Jun 3;20[1]:267. doi: 10.1186/s12872-020-01556-4.

18. Lozano Granero VC, Fernández Santos S, Fernández-Golfín C, González Gómez A, Plaza Martín M, de la Hera Galarza JM, et al.; SITAR [Strain Imaging in Transcatheter Aortic-valve Replacement] group. Sustained Improvement of Left Ventricular Strain following Transcatheter Aortic Valve Replacement. Cardiology. 2019; 143 [1]:52-61. doi: 10.1159/000500633.

19. Kafa R, Kusunose K, Goodman AL, Svensson LG, Sabik JF, Griffin BP, Desai MY. Association of Abnormal Postoperative Left Ventricular Global Longitudinal Strain With Outcomes in Severe Aortic Stenosis Following Aortic Valve Replacement. JAMA Cardiol. 2016 Jul 1;1[4]:494-6. doi: 10. 1001/jamacardio.2016.1132.

20. Abdelshafy M, Mohamed AA, Alsaileek A, Bukamseen M, Estacio EG, Alshayeb N, Warsame T, Omran AS. 39. Speckle tracking echocardio-graphy in patients with severe aortic stenosis and preserved ejection fraction undergoing aortic valve replacement. J Saudi Heart Assoc. 2015 Oct 1;27[4]:315. doi: 10.1016/j.jsha.2015.05.220.

21. Miyazaki S, Daimon M, Miyazaki T, Onishi Y, Koiso Y, Nishizaki Y, *et al.* Global longitudinal strain in relation to the severity of aortic stenosis: a two-dimensional speckle-tracking study. Echocardio-graphy. 2011 Aug;28[7]:703-8. doi: 10.1111/j.1540-8175.2011.01419.x.

22. Hulshof HG, van Oorschot F, van Dijk AP, Hopman MTE, George KP, Oxborough DL, Thijssen DHJ. Changes in dynamic left ventricular function, assessed by the strain-volume loop, relate to reverse remodeling after aortic valve replacement. J Appl Physiol [1985]. 2019 Aug 1;127[2]:415-422. doi: 10.1152/japplphysiol.00190.2019.

23. Lancellotti P, Donal E, Magne J, Moonen M, O'Connor K, Daubert JC, Pierard LA. Risk stratification in asymptomatic moderate to severe aortic stenosis: the importance of the valvular, arterial and ventricular interplay. Heart. 2010 Sep; 96[17]:1364-71. doi: 10.1136/hrt.2009.190942.

24. Yingchoncharoen T, Gibby C, Rodriguez LL, Grimm RA, Marwick TH. Association of myocardial deformation with outcome in asymptomatic aortic stenosis with normal ejection fraction. Circ Cardiovasc Imaging. 2012 Nov;5[6]: 719-25. doi: 10.1161/CIRCIMAGING.112.977348.

25. Nagata Y, Takeuchi M, Wu VC, Izumo M, Suzuki K, Sato K, *et al.* Prognostic value of LV deformation parameters using 2D and 3D speckle-tracking echocardiography in asymptomatic patients with severe aortic stenosis and preserved LV ejection fraction. JACC Cardiovasc Imaging. 2015 Mar;8[3]:235-245. doi: 10.1016/j.jcmg.2014. 12.009.

IJMA
International Journal Of Medical Arts

International Journal of Medical Arts

https://ijma.journals.ekb.eg/
Print ISSN: 2636-4174
Online ISSN: 2682-3780