Prevalence of Subclinical Left Ventricular Dysfunction in Patients with Aortic Valve Sclerosis with Normal LV geometry

Miss Ridamehvish Arif Sayyad[1], Dr Suhasini Atharga[2] , Dr Anshaj Mujral[3]
[1]*Echocardiographer, Department of Cardiology, Jawaharlal Nehru Medical College, KAHER, Belagavi, Karnataka, India*
[2]*Assistant Professor, Department of Cardiology, Jawaharlal Nehru Medical College, KAHER, Belagavi, Karnataka, India*
[3] *Cardiology Registrar, Department of Cardiology, Jawaharlal Nehru Medical College, KAHER, Belagavi, Karnataka, India*

Abstract - Background: Aortic valve sclerosis (AVS) is a degenerative condition characterized by thickening and calcification of the aortic valve leaflets without causing significant obstruction to blood flow. Unlike aortic stenosis, AVS does not initially lead to severe valve narrowing but may progress over time. We aimed to identify the degree of subclinical left ventricular (LV) diastolic and systolic dysfunction in patients with AVS as a function of thickening and calcification.

Objective: The primary objective of this study is to identify the degree of left ventricular [LV] diastolic and systolic dysfunction in AVS as a function of thickening and calcification by using Global Longitudinal Strain.

Methodology: This is an observational single centre study conducted from March 2024 to April 2025 at KLE's Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi, Karnataka, a tertiary care hospital of KLE Academy of Higher Education and Research (Deemed –to-be-University), Belagavi, Karnataka where we examined 100 participants with normal LV geometry and free from significant AV stenosis who underwent standard and speckle-tracking echocardiography.

Results: In the present study of total of 100 patients. 50 were AVS and 50 were NO AVS. The prevalence of subclinical LV diastolic dysfunction (E/e′ ratio ≥13) and systolic dysfunction [LV global longitudinal strain (GLS) >−17.0% for men and >−18.0% for women] were greater in AVS groups than those in no AVS group.

Conclusion: This study demonstrates that aortic valve sclerosis (AVS) is common in individuals without overt cardiovascular disease, with a prevalence of 50%. Importantly, AVS is associated with subclinical left ventricular (LV) diastolic and systolic dysfunction, even in the absence of structural LV remodelling. The findings highlight that individuals with AVS show higher rates of diastolic dysfunction (E/e′ ratio ≥13) and impaired systolic function (LV global longitudinal strain [GLS] >−17.0% for men and >−18.0% for women) compared to those without AVS.

Keywords: Aortic Valve Sclerosis, Global Longitudinal Strain, Subclinical left ventricular dysfunction

I. INTRODUCTION

Aortic valve sclerosis (AVS) characterized by thickening and calcification on the aortic valve leaflets without haemodynamically significant obstruction of left ventricular (LV) outflow is a common abnormality in the elderly.[1]

Various cardiovascular risk factors including hypertension, diabetes mellitus, hypercholesterolaemia, and cigarette smoking lead to the development of AVS.[2–4]

Previous studies have demonstrated that AVS is not a simple degenerative cardiac marker; AVS per se is associated with cardiovascular morbidity and mortality independent of traditional cardiovascular risk factors.[7,8]

Left ventricular (LV) hypertrophy has generally been considered as an adverse consequence of the pressure overload of flow-limiting AV disease and a contributor to subsequent cardiovascular events.[9–11]

Previous studies have demonstrated that the association between AVS and cardiovascular events was independent of LV hypertrophy.[7]

LV hypertrophy may occur late in response to the AV degenerative process and LV function alteration may occur with AV sclerotic changes before the manifestation of morphological remodelling. Recently, significant attention has been given to the prognostic value of preclinical LV diastolic dysfunction, defined as asymptomatic diastolic disturbance with normal LV ejection fraction.[12,13]

Speckle-tracking echocardiography is a new non-invasive imaging technique of echocardiography that allows an objective and quantitative evaluation of global and regional myocardial function.[14]

Longitudinal strain represents myocardial deformation directed from the base to the apex. Through longitudinal strain analysis in Apical 4-chamber, Apical 2-chamber, and Apical 3 chamber views, both regional (relativeto each of the17 LV segments) and global strain values (global longitudinal strain) can be obtained. Recently Global longitudinal strain has been validated as a quantitative index for global LV function.[15]

LV global longitudinal strain (GLS) is a sensitive and accurate measure for the detection of subclinical LV systolic dysfunction. GLS allows quantification and early detection of myocardial damage even when LV ejection fraction is normal.[5]

Therefore, AVS may be associated with preclinical LV systolic/diastolic functional alterations before the development of LV structural remodelling. Understanding the relationship between AVS and LV functional remodelling in the preclinical setting may provide insight into the pathophysiological mechanisms linking AVS and cardiovascular events.

This study aims to determine whether AVS is independently associated with LV systolic and diastolic functional alteration in individuals with normal LV geometry free of cardiac disease.

II. METHODS

2.1 Ethical Consideration:

The study protocol was reviewed and approved by the Institutional Ethics Committee of Jawaharlal Nehru Medical College, KAHER, Belagavi, Karnataka, India (Approval No: MDC/JNMCIEC/313). All procedures were a part of routine clinical evaluation and patient confidentiality was strictly maintained. Written informed consent was obtained from all participants prior to enrolment. The study did not impose any financial burden on the participants in any form.

2.2 Study Area

The study was conducted in KLE's Dr. Prabhakar Kore Hospital and Medical Research Centre an attached teaching hospital of KLE Academy of Higher Education and Research (Deemed-to- be-University), Belagavi, Karnataka, India from May 2024 to April 2025.

2.3 Study Design

It was a hospital based comparative study. Participants after undergoing 2D transthoracic echocardiography diagnosed with Aortic Valve Sclerosis having normal LV geometry and no significant AV stenosis underwent standard doppler and speckle-tracking echocardiographic evaluation. AVS was categorized into two groups as follows: No Aortic Valve Sclerosis and Aortic Valve Sclerosis (AV thickening or calcification on one leaflet or ≥2 leaflets). The prevalence of subclinical LV diastolic dysfunction (E/e′ ratio ≥13) and systolic dysfunction [LV global longitudinal strain (GLS) ≥-17 in Men and ≥-18 in Women in participants with Aortic Valve Sclerosis were compared with normal population.

2.4 Study Population

Patients undergoing 2D Transthoracic echocardiography and diagnosed with Aortic Valve Sclerosis underwent a detailed doppler and speckle tracking transthoracic echocardiographic evaluation. The normal population were selected on the basis of clinical history and results from 2D Transthoracic echocardiography exam results which includes normal heart chamber sizes, normal wall thickness, normal valve function, and absence of any structural defects or abnormalities in the heart's anatomy additionally, normal blood flow patterns and absence of any signs of cardiac dysfunction or disease. Results from both the populations were compared. The study was conducted in KLE'S DR PRABHAKAR KORE Hospital & MRC Belagavi, Karnataka.

2.5 Data Collection Technique

The entire transthoracic 2D-echo of the chosen patient was performed and the results were recorded in the predesigned proforma.

The following tests were performed on all patients:

•Electrocardiogram

•Echocardiography: Routine 2D

Echocardiography was performed on all of the patients.

2.6 Statistical Analysis

The data collected was entered into Microsoft Excel, and is coded in the worksheet. The categorical data was expressed as frequency and percentage. The continuous variables were presented with mean ± standard deviation (SD) or median and interquartile range (IQR) after analysis. The comparison of continuous variables was done using t-test for data which followed normal distribution, and for the data which is not normally distributed, Wilcoxon signed rank test was used. All the tests were two-tailed and a p-value of < 0.05 was considered significant.

2.7 Inclusion Criteria

1. Patients within the age group of 18 to 85 yearsPresence of Aortic valve sclerosis verified by 2D Transthoracic echocardiography.
2. Patients with sinus rhythm.
3. Patients with mild to moderate Aortic Regurgitation

2.8 Exclusion Criteria

1. Patients with Atrial Fibrillation.
2. History of Coronary Artery Disease
3. LVEF <50%
4. Other Significant Valve Diseases (Tricuspid, Pulmonary, Mitral)
5. Presence of congenital heart diseases
6. Presence of prosthetic valves.
7. Presence of moderate to severe pulmonary hypertension
8. Presence of severe Aortic Regurgitation
9. Bicuspid Aortic Valve
10. Aortic Stenosis with velocity >2.6m/s
11. Presence of LVH

III. RESULTS

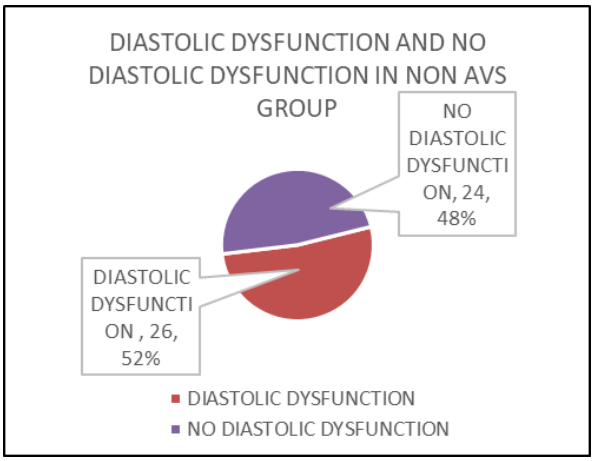

Figure 1

Figure 1 represents data of non-AVS group, 26 have diastolic dysfunction, while 24 do not, showing almost equal distribution among participants. For the non-Aortic Valve Sclerosis (AVS) group, 26 out of 50 individuals experience diastolic dysfunction, while 24 do not. This near-equal distribution shows that diastolic dysfunction affects around 52% of the participants, indicating that diastolic dysfunction is common even in those without AVS. The nearly balanced nature of these numbers highlights that diastolic health varies widely among individuals.

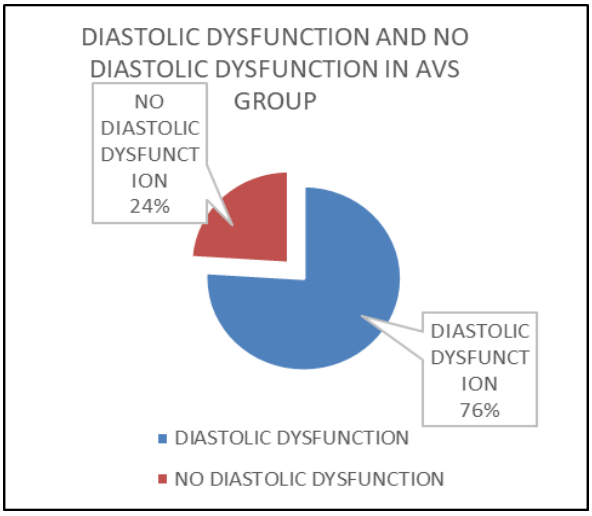

Figure 2

Figure 2 represents distribution of study population according to diastolic dysfunction in AVS group. This data shows the distribution of patients with and without diastolic dysfunction in population with aortic valve sclerosis (AVS). Based on the provided data of total 50 individuals with AVS, 38 have diastolic dysfunction,

while 12 do not. This implies that a significant majority of individuals (76%), experience issues with the heart's ability to relax and fill properly. Understanding and addressing diastolic dysfunction in AVS patients could be crucial for improving their overall heart health and quality of life. The remaining 24% of individuals do not have this difficulty, highlighting the variability in heart condition.

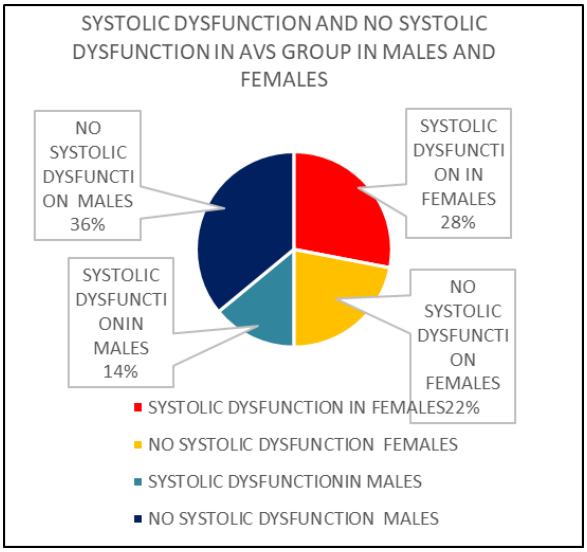

Figure 3

Figure 3 shows distribution of study population according to systolic dysfunction in AVS groups in males and females.In the Aortic Valve Sclerosis (AVS) group, systolic dysfunction is more prevalent among females, with 14 out of 25 subjects experiencing it compared to 11 patients who do not. Conversely, only 7 out of 25 males have systolic dysfunction, while 18 did not. This suggests that females with AVS are more prone to issues with the heart's systolic function. The total of 50 participants highlights the importance of gender-specific considerations in managing heart health in AVS patients.

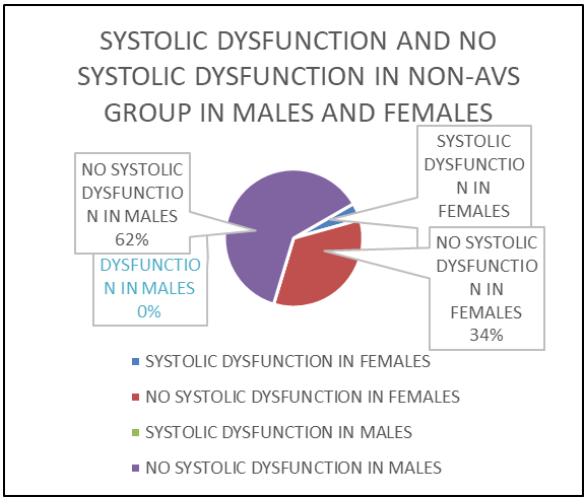

Figure4

Figure 4 represents Distribution of study population according to systolic dysfunction in non AVS group. In the non-Aortic Valve Sclerosis (non-AVS) group, systolic dysfunction is quite rare. Among females, only 2 out of 19 have it, while 17 do not. The study revealed that no males were seen to experience systolic dysfunction in this group. Out of the total 50 participants, the vast majority do not face issues with the heart's pumping ability, highlighting good systolic function in this population.

	NO AVS	AV thickened	Calcification on 1 leaflet	Calcification on >2 leaflet	p-value
LV end-diastolic diameter,	4.455±0.41	4.5344±0.50	4.3193±0.386	4.56±0.41	<0.001
LV end-systolic diameter,	2.9476±0.386	2.962±0.432	2.888±0.360	3.071±0.453	<0.001
LV ejection fraction	61.854±6.391	62.891±9.114	64.944±4.570	61.363±5.299	0.044
LV mass index	75.842±16.688	81.157±23.114	79.573±19.037	85.613±20.710	<0.001
E wave, cm/s	85.654±22.148	80.628±23.347	79.594±20.069	72.419±16.757	0.077
A wave, cm/s	71.314±14.606	98.933±17.926	93.231±16.015	91.938±17.703	0.08
E/A ratio	1.236±0.398	0.811±0.197	0.894±0.336	0.813±0.209	0.018
e′, cm/s	9.890±2.994	7.537±2.437	7.312±1.293	6.663±1.374	0.372
E/e′ ratio	8.8954±2.171	11.117±3.435	10.938±2.218	11.175±2.924	0.036
LVGLS, %	-20.396±8.768	-20.478±1.615	-18.494 ±2.673	-15.738±0.869	<0.001
Aortic Peak Velocity	1.270±0.105	1.856±0.212	1.900±0.231	1.888±0.320	0.041

Table 1: Echocardiographic measurements stratifying the extent of AVS:

The prevalence of subclinical LV diastolic and systolic dysfunction were greater in AVS groups than in non AVS group. AVS was observed in 50% individuals without cardiac disease and was associated with subclinical LV diastolic and systolic dysfunction even in the absence of LV morphological change. These findings underscore the importance of early detection and management of aortic valve conditions to maintain optimal heart health. Understanding these variations can help tailor personalized treatment strategies for better patient outcomes.

IV. DISCUSSION

This study includes all the variables of LV function, including the LV systolic and diastolic diameter, LA diameter, LV systolic and diastolic volume, LV Ejection-fraction, diastolic dysfunction along with 2-D conventional parameter, Speckle Tracking Echocardiography.

The study was conducted from April 2024 to March 2025 in KLE'S Dr. Prabhakar Kore hospital and Medical Research Centre, Belagavi Karnataka, which is attached teaching hospital to KLE Academy of higher Education and Research (Deemed-to-be-University) Belagavi, Karnataka.

In the present study total of 100 individuals- No AVS (50%), half of the population studied showed no aortic valve impairment, AV Thickened (19%) nearly one-fifth of the cases have thickened aortic valves, Calcification on 1 Leaflet (16%), Calcification on >2 Leaflets (15%).

In this present study in the AVS group with 50 individuals, only 5 (10%) are between 18-44 years old, emphasizing that younger people are less affected. The prevalence increases significantly in the middle age, with 20 people (40%) aged between 45-65yrs. The highest frequency is seen in those aged 65 and above, with 25 individuals (50%).

The LV Mass Index increases progressively in both males and females. Males consistently have higher LV Mass Index values than females. Throughout the graph, the male LV Mass Index remains higher than the female values, reflecting known physiological and anatomical differences in heart structure. This suggests potential variability of LV Mass index according to Sex and BMI. ($p<0.001$)

In this study we have proven that there was significant association between AVS and diastolic dysfunction. Out of total 50 individuals, 38 individuals with Aortic Valve Sclerosis (AVS) have diastolic dysfunction, while 12 do not. This means that a significant majority, about 76%, experience issues with the heart's ability to relax and fill properly. The remaining 24% of individuals did not have this complication. ($p=0.036$)

In the non-Aortic Valve Sclerosis (AVS) group, 26 out of 50 individuals experience diastolic dysfunction, while 24 do not. This near-equal distribution shows that diastolic dysfunction affects around 52% of the participants, indicating that diastolic dysfunction is common even in those without AVS. ($p=0.036$)

In the non-Aortic Valve Sclerosis (non-AVS) group, systolic dysfunction is quite rare. Among females, only 2 out of 19 have it, while 17 do not. No males experience systolic dysfunction in this group, with all 31 being free of it. Out of the total 50 participants, the vast majority do not face issues with the heart's pumping ability, highlighting good systolic function in this population. ($p<0.001$)

In the Aortic Valve Sclerosis (AVS) group, subclinical LV systolic dysfunction is more prevalent among females, with 14 out of 25 experiencing it compared to 11 who do not. Conversely, only 7 out of 25 males have systolic dysfunction, while 18 do not. This suggests that individuals with AVS are more prone to issues with the heart's pumping ability. The total of 50 participants highlights the importance of gender-specific considerations in managing heart health in AVS patients. ($p<0.001$)

Coincidentally, we also found that females are more prone to have subclinical systolic dysfunction in both AVS and Non AVS groups as compared to males.

Correlation between E/e' and LVGLS (%) in AVS group suggests a progressive decline in both diastolic and systolic function in AVS. Higher E/e' ratios (diastolic dysfunction) correlate with worsening LVGLS% (systolic dysfunction). This relationship highlights a strong link between diastolic dysfunction and myocardial strain impairment in AVS.

Correlation between E/e' and LVGLS (%) in non AVS group show that these individuals have relatively preserved diastolic (lower E/e') and systolic function (more negative LVGLS%) indicating that these groups do not have subclinical diastolic and systolic dysfunction.

V. CONCLUSION

This study demonstrates that aortic valve sclerosis (AVS) is common in individuals without overt cardiovascular disease, with a prevalence of 50%. Importantly, AVS is associated with subclinical left ventricular (LV) diastolic and systolic dysfunction, even in the absence of structural LV remodelling. The findings highlight that individuals with AVS show higher rates of diastolic dysfunction (E/e′ ratio ≥13) and impaired systolic function (LV global longitudinal strain [GLS] >−17.0% for men and >−18.0% for women) compared to those without AVS.

These results suggest that AVS is not merely an incidental finding but may serve as an early marker of cardiac dysfunction. The progression of AVS appears to correlate with worsening LV function, reinforcing the need for early detection and monitoring in affected individuals.

VII.LIMITATIONS

The present study has several limitations that should be acknowledged:

First, strain imaging is highly dependent on image quality. Suboptimal acoustic windows, particularly in older individuals and those with obesity or chronic lung disease, may have affected strain measurements and resulted in the exclusion of some segments or participants, potentially introducing selection bias.

Second, the study focused primarily on global longitudinal strain, and other strain components such as circumferential or radial strain were not systematically assessed. These additional parameters may provide complementary information regarding myocardial mechanics in aortic valve sclerosis.

Third, vendor-specific software and algorithms were used for strain analysis. This limits the generalizability of the results, as strain values may vary across different echocardiographic platforms and post-processing software. Inter-vendor variability remains an important challenge in strain imaging.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Conflicts Of Interest: The author(s) declare no conflicts of interest with respect to the research, authorship or publication of this article.

REFERENCES

[1] *Stewart BF, Siscovick D, Lind BK, Gardin JM, Gottdiener JS, Smith VE, Kitzman DW, Otto CM. Clinical factors associated with calcific aortic valve disease. Cardiovascular Health Study. J Am Coll Cardiol. 1997;29(3):630-4. doi: 10.1016/s0735-1097(96)00563-3.*[1]

[2] *Iwata S, Russo C, Jin Z, Schwartz JE, Homma S, Elkind MS, Rundek T, Sacco RL, Di Tullio MR. Higher ambulatory blood pressure is associated with aortic valve calcification in the elderly: a population-based study. Hypertension. 2013;61(1):55-60. doi: 10.1161/HYPERTENSIONAHA.112.202697.*[2]

[3] *Yamaura Y, Watanabe N, Shimaya M, Tomita Y, Fukaya T, Yoshida K. Impact of cumulative smoking exposure on subclinical degenerative aortic valve disease in apparently healthy male workers. Circ Cardiovasc Imaging. 2019;12(8):e008901. doi: 10.1161/CIRCIMAGING.119.008901.*[3]

[4] *Utsunomiya H, Yamamoto H, Kunita E, Hidaka T, Kihara Y. Insulin resistance and subclinical abnormalities of global and regional left ventricular function in patients with aortic valve sclerosis. Cardiovasc Diabetol. 2014;13:86. doi: 10.1186/1475-2840-13-86.*[4]

[5] *Magne J, Cosyns B, Popescu BA, Carstensen HG, Dahl J, Desai MY, Kearney L, Lancellotti P, Marwick TH, Sato K, Takeuchi M, Zito C, Casalta AC, Mohty D, Piérard L, Habib G, Donal E. Distribution and prognostic significance of left ventricular global longitudinal strain in asymptomatic significant aortic stenosis: An individual participant data meta-analysis. JACC Cardiovasc Imaging. 2019;12(1):84-92. doi: 10.1016/j.jcmg.2018.11.005.*[5]

[6] *Coffey S, Cox B, Williams MJ. The prevalence, incidence, progression, and risks of aortic valve sclerosis: a systematic review and meta-analysis. J Am Coll Cardiol. 2014;63(25 Pt A):2852-61. doi: 10.1016/j.jacc.2014.04.018.*[6]

[7] *Otto CM, Lind BK, Kitzman DW, Gersh BJ, Siscovick DS. Association of aortic-valve sclerosis*

with cardiovascular mortality and morbidity in the elderly. N Engl J Med. 1999;341(3):142-7. doi: 10.1056/NEJM199907153410302.[7]

[8] *Christensen JL, Tan S, Chung HE, Ghosalkar DS, Qureshi R, Chu A, Yu W, Berus J, Shah NR, Wu WC, Chun H, Aikawa E, Choudhary G, Morrison AR. Aortic valve calcification predicts all-cause mortality independent of coronary calcification and severe stenosis. Atherosclerosis. 2020;307:16-20. doi: 10.1016/j.atherosclerosis.2020.06.019. Epub 2020 Jul 8. PMID: 32702536; PMCID: PMC7583087.*[8]

[9] *Agno FS, Chinali M, Bella JN, Liu JE, Arnett DK, Kitzman DW, Oberman A, Hopkins PN, Rao DC, Devereux RB. Aortic valve sclerosis is associated with preclinical cardiovascular disease in hypertensive adults: the Hypertension Genetic Epidemiology Network study. J Hypertens. 2005;23(4):867-73. doi: 10.1097/01.hjh.0000163157.14493.c7.*[9]

[10] *Pellikka PA, Sarano ME, Nishimura RA, Malouf JF, Bailey KR, Scott CG, Barnes ME, Tajik AJ. Outcome of 622 adults with asymptomatic, hemodynamically significant aortic stenosis during prolonged follow-up. Circulation. 2005;111(24):3290-5. doi: 10.1161/CIRCULATIONAHA.104.495903.*[10]

[11] *Ito N, Zen K, Takahara M, Tani R, Nakamura S, Fujimoto T, Takamatsu K, Yashige M, Kadoya Y, Yamano M, Yamano T, Nakamura T, Yaku H, Matoba S. Left ventricular hypertrophy as a predictor of cardiovascular outcomes after transcatheter aortic valve replacement. ESC Heart Fail. 2023;10(2):1336-46. doi: 10.1002/ehf2.14305.*[11]

[12] *Echouffo-Tcheugui JB, Erqou S, Butler J, Yancy CW, Fonarow GC. Assessing the risk of progression from asymptomatic left ventricular dysfunction to overt heart failure: A systematic overview and meta-analysis. JACC Heart Fail. 2016;4(4):237-248. doi: 10.1016/j.jchf.2015.09.015.* [12]

[13] *Gong FF, Campbell DJ, Prior DL. Noninvasive cardiac imaging and the prediction of heart failure progression in preclinical stage A/B subjects. JACC Cardiovasc Imaging. 2017;10(12):1504-1519. doi: 10.1016/j.jcmg.2017.11.001.* [13]

[14] *Dandel M, Lehmkuhl H, Knosalla C, Suramelashvili N, Hetzer R. Strain and strain rate imaging by echocardiography - basic concepts and clinical applicability. Curr Cardiol Rev. 2009;5(2):133-148. doi: 10.2174/157340309788166642.*[14]

[15] *Brown J, Jenkins C, Marwick TH. Use of myocardial strain to assess global left ventricular function: a comparison with cardiac magnetic resonance and 3-dimensional echocardiography. Am Heart J. 2009;157(1):102.e1-102.e1025. doi: 10.1016/j.ahj.2008.08.032.*[15]

[16] *Bozbas H, Pirat B, Yildirir A, Simşek V, Sade E, Eroglu S, Atar I, Altin C, Demirtas S, Ozin B, Muderrisoglu H. Coronary flow reserve is impaired in patients with aortic valve calcification. Atherosclerosis. 2008;197(2):846-852. doi: 10.1016/j.atherosclerosis.2007.07.036.*[16]

[17] *Han D, Cordoso R, Whelton S, Rozanski A, Budoff MJ, Miedema MD, Nasir K, Shaw LJ, Rumberger JA, Gransar H, Dardari Z, Blumenthal RS, Blaha MJ, Berman DS. Prognostic significance of aortic valve calcium in relation to coronary artery calcification for long-term, cause-specific mortality: Results from the CAC Consortium. Eur Heart J Cardiovasc Imaging. 2021;22(11):1257-1263. doi: 10.1093/ehjci/jeaa336.*[17]

[18] *Poggianti E, Venneri L, Chubuchny V, Jambrik Z, Baroncini LA, Picano E. Aortic valve sclerosis is associated with systemic endothelial dysfunction. J Am Coll Cardiol. 2003;41(1):136-41.*[18]

[19] *Kosmala W, Marwick TH. Asymptomatic left ventricular diastolic dysfunction: predicting progression to symptomatic heart failure. JACC Cardiovasc Imaging. 2020;13(2):215-27.*[19]