Med. J. Cairo Univ., Vol. 90, No. 7, December: 2021-2026, 2022
www.medicaljournalofcairouniversity.net

Improvement on Left Ventricular Function Assessed by Speckle Tracking Echocardiography after Aortic Valve Replacement for Severe Aortic Stenosis

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Abstract

Background: Calcification of a congenitally existing bicuspid or trileaflet valve is a common cause of aortic stenosis; rheumatic illness also plays a role. Left ventricular heart failure in particular has been linked to an elevated mortality risk in patients with severe AS, and this dysfunction remains over time. Serious problems and even mortality might occur when AS leads to LV failure.

Aim of Study: Assess the value of 2D speckle tracking echocardiography in detection of LV improvement after AVR in patients with severe aortic stenosis.

Patients and Methods: This research was conducted in Islamic Center of Cardiology, Al-Azhar University. From January 2020 to March 2022. The research included 40 patients suffer from severe aortic stenosis (AS). AVR was done in the Cardiothoracic Surgery units of the Faculty of Medicine, Al-Azhar University.

Results: Except for LVEDV, there was no notable change in echocardiographic data after 1 week of AVR. There was a substantial change in echocardiographic data at baseline after 1 month, with the exception of LVEF and GCS. With the exception of LVEF, there was a significant change in echocardiographic data at 3 months.

Conclusion: Early recovery of LV longitudinal function is indicated by the improvement in GLS seen 3 months after AVR, despite the lack of a substantial change in LV ejection fraction.

Key Words: *Speckle tracking – Echocardiography – Aortic stenosis – LV function.*

Introduction

RHEUMATIC illness or, more typically, calcification of a congenitally bicuspid or trileaflet valve may induce aortic stenosis. Aortic stenosis prevalence rises with age, averaging 0.2% in the 50-59 age group and reaching 9.8% in the 80-89 age group. Endothelial damage, lipid penetration, fibrosis, leaflet thickening, and eventually calcification culminate in aortic stenosis [1].

Those who suffer from severe aortic stenosis (AS) often have left ventricular (LV) hypertrophy and dysfunction as a result of the left ventricle being subjected to excessive pressure for extended periods of time. Symptoms of aortic stenosis (which include angina, dyspnea, and syncope) affect more than a third of those with severe aortic stenosis, as shown by studies [2].

In severe AS, cardiac dysfunction persists over time, and it is particularly left ventricular heart failure that has been related to an increased risk of death. One of the potential advantages of AVR is a decrease in the risk of sudden mortality, while another is improved left ventricular function [3].

Without surgical therapy, a person with severe aortic stenosis and congestive heart failure has a life expectancy of fewer than two years [4].

The treatment of aortic valve disease, particularly stenosis, has progressed through time, from medicinal therapy and balloon valvuloplasty to the current gold standard surgical surgery. Due to surgical innovation, intraoperative and postoperative patient monitoring, hemodynamic malfunction awareness, and prosthesis selection, traditional surgical aortic valve replacements are presently being challenged in moderate and high-risk patients [5].

When the LV fails in a person with AS, it may lead to serious complications or even death. Aortic stenosis patients, the vast majority of whom have an otherwise normal ejection fraction, may be accurately diagnosed with mild left ventricular

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(LV) failure using speckle tracking echocardiography [2].

Many recent investigations have shown that global myocardial strain has prognostic value. Our work may aid in better determining the prognosis of such individuals by recognising this little LV dysfunction. Recognizing mild myocardial failure at an early stage may have therapeutic implications since LV strain performance deteriorates with time in untreated people [6].

Speckle tracking echocardiography will be used in ongoing research to assess left ventricular function after aortic valve replacement for severe aortic stenosis.

Material and Methods

This was a study done in Islamic Center of Cardiology, Al-Azhar University. From January 2020 to March 2022. All patients under went AVR at the Cardiothoracic Surgery Units at the Faculties of Medicine of Al-Azhar university, Cairo.

Inclusion criteria:

Patients scheduled for AVR at the hospital for symptomatic-severe valvular aortic stenosis were screened, and 40 patients met the inclusion criteria for severe AS.

Ethical approval:

The research was authorised by the university's ethical committee, and all participants provided written informed permission. This research was done in an ethical manner, as outlined in the World Medical Association's Declaration of Helsinki (Declaration of Helsinki).

Severe AS is defined as an Aortic V max of 4m/s or more, a mean pressure gradient of 40mm Hg or more, and an AVA of $1.0cm^2$ or less (angina, dyspnea and syncope in aortic stenosis).

Exclusion criteria:

Patients were excluded if they had any of the following:

- Prior cardiac surgery, including concurrent coronary artery bypass graft surgery (CABG).
- A poor echo window and low tracking quality on strain imaging.
- Patients later discovered to have prosthesis malfunction.
- Patients with a history of hypertension.

All the standard checks, including a complete medical history, physical exam, and functional class according to the New York Heart Association, were recorded. One, two, and three months following the pre-AVR detailed echo with speckle tracking, readings were collected (per Echo protocol). (Using LVEDV, LVESV, EF, Global Longitudinal Peak Strain, and Global Circumferential Peak Strain as independent variables, we conducted statistical computations and analysis).

Echocardiography protocol:

Commercially available S5-1 echocardiographic devices were employed in this study (1-5Mhz). Fifteen percent of the recorded echocardiographic tests were verified by a second observer. Traditional echocardiograms, two-dimensional echocardiograms, and speckle tracking echocardiograms were performed before operation, and then again a week after AVR, then again a month and three months afterwards.

The pictures were analysed using the GE Healthcare Echo Pak. Patients were digitally recorded as they lay supine on their left sides and held their breath for three complete cardiac cycles.

We assessed left ventricular (LV) ejection fraction, end diastolic volume, and systolic volume using the biplane Simpson's approach (LVESV). Using deductive and inductive reasoning that follows the 2019 ASCET guidelines [7].

The aortic valve's surface area may be calculated using the continuity equation.

(AVA = CSALVOT * VTILVOT / VTIAV) is the formula for the area of the aortic valve, where CSALVOT is the cross sectional area of the LVOT, VTI LVOT is the velocity time integral of the LVOT, and VTI AV is the velocity time integral of the aortic valve.

Conventional parasternal short-axis pictures will be acquired at the base, papillary muscles, and apex for STE analysis, along with apical four, three-, and two-chamber views at frame rates ranging from 50 to 80 fps. In order to determine velocity and myocardial deformation, this method employs a tracking algorithm that can detect intrinsic acoustic markers ('features') of the heart and then track their movements from frame to frame.

The septum, lateral wall, anterior wall, inferior wall, anteroseptal wall, and posterior wall of the left ventricle were all removed and studied separately. To further dissect the septum, it was divided into three sections at its base, two at its median, and five at its tip (anterior, septal, inferior, lateral and apex). The longitudinal strain of all 17 segments was measured. Circumferential strain will be assessed over nine different parasternal short-axis view segments: Three at the base, three in the middle, and four at the top (CS). Automated segmental peak strain averaging is included in the programme (Global longitudinal strain and Global circumferential strain).

Statistical analysis:

IBM SPSS version 22.0 was used to analyses computer-generated data. To express quantitative data, percentages and numbers were employed. Before utilizing the median in nonparametric analysis or the interquartile range in parametric analysis, it was required to perform Kolmogorov-Smirnov tests to ensure that the data were normal. We used the (0.05) significance threshold to establish the significance of the findings. The Chi-Square test is used to compare two or more groups. The Monte Carlo test may be used to adjust for any number of cells with a count less than 5. Fischer Chi-Square adjustment was applied to tables demonstrating non continuous data.

Results

In our study males were 21 (52.5%) and females were 19 (47.5%). Mean age was 61.6 years with SD of 2.3. 9 (22.5%) patients wre diabetics and 12 (30%) were smokers. Mean blood pressure was 125.6/84.3mmHg. Body Surface Area was 1.6m^2. Mean hemoglobin was 11.1g/dl. Mean Serum Creatinine was 1.1mg/dl. Hypercholesterolemia was observed in 8 (20%) cases. NYHA I,II,III and IV were 0,7,27 and 6.

Table (1): Patients basal characteristics.

	Aortic stenosis patients
Gender (n, %):	
Males	21 (52.5%)
Females	19 (47.5%)
Age (years)	61.6±2.3
Diabetes (n/%)	9 (22.5%)
Smoker (n/%)	12 (30%)
Systolic Blood Pressure (mmHg)	125.6±5.6
Diastolic Blood Pressure (mmHg)	84.3±5.6
Body Surface Area (m^2)	1.6±0.3
Hemoglobin (g/dl)	11.1±1.6
Serum Creatinine (mg/dl)	1.1±0.2
Hypercholesterolemia (n,%)	8 (20%)
NYHA Functional Class:	
NYHA I	0
NYHA II	7 (17.5%)
NYHA III	27 (67.5%)
NYHA IV	6 (15%)

Table (2): Echocardiographic findings of patients with severe aortic stenosis.

	Before AVR		1 week after AVR			1 month after AVR			3 months after AVR		
	Mean	SD	Mean	SD	*p*-value	Mean	SD	*p*-value	Mean	SD	*p*-value
LVEDV	101.6	14.3	94.8	13.8	0.005	92.1	12.9	0.0001	93.5	11.4	0.0003
LVESV	55.7	10.3	53.2	9.9	0.145	49.4	10.1	0.0001	39.8	9.8	0.0001
LVEF	44.2	14.8	42.9	15.1	0.607	45.6	13.1	0.554	48.6	13.4	0.067
GLS	–10.9	3.9	–11.3	3.8	0.539	–14.2	4	0.0001	–19.4	3.8	<0.0001
GCS	–17.3	4.5	–15.6	4.2	0.0773	–18.1	4.4	0.289	–21.4	3.6	<0.0001

LVEDV : Left ventricular end diastolic volume.
LVESV : Left ventricular end stroke volume.
LVEF : Left ventricular ejection fraction.
GLS : Global longitudinal strain.
GCS : Global circumferential strain.

There was no significant change in echocardiographic data from baseline after 1 week of VAR, with the exception of LVEDV. With the exception of LVEF and GCS, the echocardiographic values at baseline had changed significantly after 1 month. Echocardiographic data from before 3 months showed significant change, with the exception of LVEF.

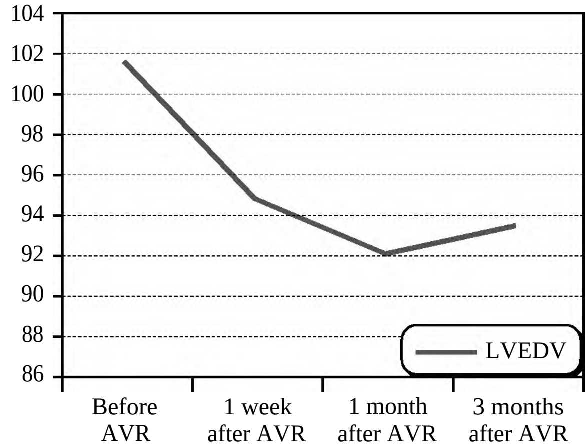

Fig. (1): LVEDV value through the study and follow-up.

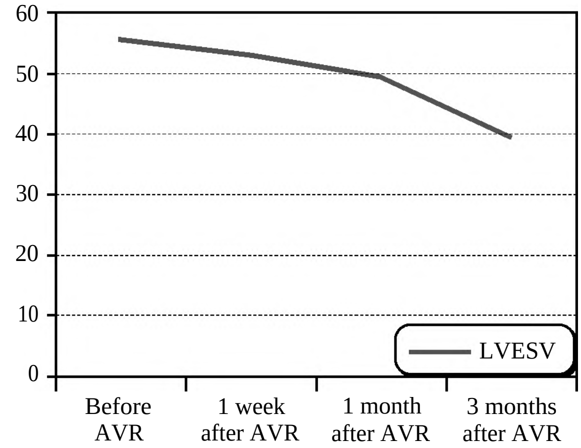

Fig. (2): LVESV value through the study and follow-up.

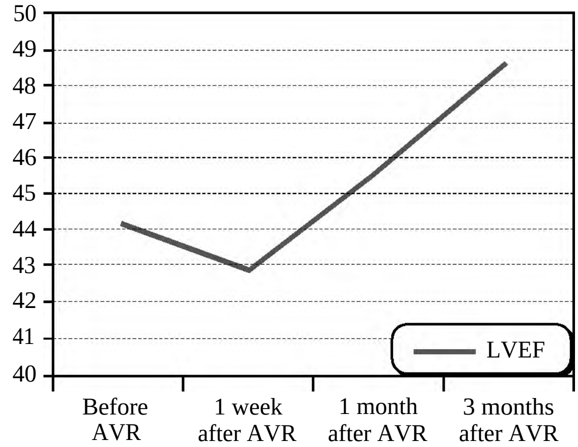

Fig. (3): LVEF value through the study and follow-up.

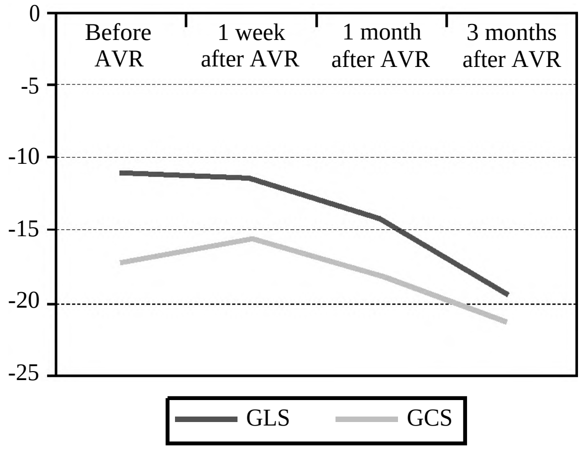

Fig. (4): GLS & GCS value through the study and follow-up.

Discussion

The three-month follow-up was successful for 40 patients who volunteered to be monitored. While many patients had an intact ejection fraction, lower GLS and GCS values at baseline suggested latent LV dysfunction. The improvement in GLS/GCS over the first three months after AVR was noteworthy in comparison to the modest and constrained recovery in ejection%.

When GLS/GCS is employed in addition to the traditional markers of 2D echocardiography (LVDEV/LVESV/LVEF), diagnostic accuracy is improved by a factor of two. Statistically substantial decreases in global longitudinal strain and global circumferential strain were seen as early as three months after aortic valve replacement.

Additionally, higher GLS and GCS baseline values were associated with greater long-term LV function recovery. The importance of early diagnosis of LV dysfunction using GLS and GCS is underscored by the fact that postponing aortic valve replacement is linked with poorer LV recovery in individuals with lower global longitudinal and global circumferential strain at baseline.

When comparing several methods of assessing LV health and function, including as ejection fraction, end-diastolic volume, and systolic volume, speckle tracking has been shown to be more sensitive to changes. Our results lend credence to the idea that strain analysis may be used to proactively detect those who require an aortic valve replacement. Additional research came to the same conclusion.

Recovery of LV longitudinal performance occurs early, as shown by the fact that GLS improves three months following AVR while LV ejection fraction stays stable **[8]**. At one week post-AVR, global longitudinal strain (GLS) was similar to pre-AVR levels, but by three months, GLS had decreased significantly. In the same way, both the global circumferential strain (GCS) and the global radial strain (GRS) were unremarkable (GRS). One week following AVR treatment, there was a significant rise in the ejection fraction.

Three months following AVR, the GLS improves dramatically independent of the AS subtype, as shown by speckle tracking strain analysis, and an upward trend is seen as early as week one. The LV's longitudinal function is controlled by the predominantly longitudinal subendocardial myocytes, whereas the LV's circumferential and radial functions are controlled by the midwall helicoidal fibres [9]. The longitudinal subendothelial fibres of the aortic stenosis are particularly sensitive to the decrease in coronary blood flow brought on by left ventricular hypertrophy and left ventricular pressure overload [10].

The quick improvement in LV longitudinal performance after stenotic aortic valve replacement is consistent with the theory that this fragility is responsible [11]. Because LVEF remained stable throughout the study, the rise in GLS after 3 months of follow-up cannot be attributed to an increase in LVEF. Instead, it is likely attributable to the recovery of longitudinal subendocardialfibres after AVR to decrease LV pressure overload [12].

According to the findings, LVGLS was 16.2% on average (range from 5.6-30.1%). To wit: (Magne et al., 2019) [13]. Overall, 75 percent of patients had an LVGLS of more than 13.7 percent, and 15 percent had an LVGLS of more than 20 percent. (This shows the LV's ability to operate longitudinally was not compromised). Among patients with severe AS, the median LVGLS was 16.3% (range: 6% to 30.1 %). In addition, GLS (global longitudinal strain) was also shown to be greatly improved after AVR [14].

While the systolic pulmonary artery pressure had fallen considerably by 53.9 days post-TAVI, neither the LVEF nor the diastolic function had altered statistically [15]. (PAP) Even while global longitudinal strain (GLS) didn't alter much after TAVI, there was an increase in GRS in the centre of the left ventricle (LV). The longitudinal strain quickly returned to normal in the dorsolateral and anteroseptal portions of the base. Also, radial shear stress (RSAS) at the midsagittal and midanteroseptal levels decreased (p=0.038 and 0.001, respectively). Over the course of the extended follow-up period, there was a significant reduction in LV mass index.

Patients with significant aortic stenosis before and after AVR were retrospectively analysed by Kafa et al. [16]; all patients included had intact ejection fraction. As the GLS values improved from -14.8% before AVR to -17.2% after AVR, the extended follow-up was not a major concern. To emphasise the need of prompt treatment in patients with severe aortic stenosis, only 20% of patients who survived more than a year after aortic valve replacement showed LVEF preservation and apparent left ventricular mass decrease.

Conclusion:

Despite no change in LV ejection fraction, GLS improves three months following AVR, demonstrating that LV longitudinal function recovers quickly after surgery.

Conflict of interest: The authors declare no conflict of interest.

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

Author contribution: Authors contributed equally in the study.

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تقييم تحسين وظيفة البطين الأيسر بإستخدام تقنية التتبع النقطى للموجات فوق الصوتية للقلب بعد استبدال الصمام الأورطى جراحيا لحالات الضيق الشديد بالصمام

الخلفية : تكلس الصمام الأورطى الثنائى الشرف الموجود خلقياً أو الصمام الثلاثى هو سبب شائع لتضيق الصمام الأورطى. وأيضاً يلعب المرض الروماتيزمى دوراً فى تضيق الصمام. تم ربط قصور القلب البطينى الأيسر على وجه الخصوص بارتفاع مخاطر الوفيات فى المرضى الذين يعانون ضيق شديد بالصمام الأورطى، ويظل هذا الخلل الوظيفى مع مرور الوقت. وقد تحدث مشاكل خطيرة وحتى الموت عند ما يؤدى ضيق الأورطى إلى فشل البطين الأيسر.

الهدف : لإستخدام الموجات الصوتية للقلب بتقنية التتبع النقطى فى تحديد مقدار التحسن فى وظيفة البطين الأيسر بعد استبدال الصمام الأورطى للمرضى الذين يعانون من ضيق شديد بالصمام الأورطى.

طرق البحث : تم إجراء هذا البحث فى المركز الإسلامى لأمراض القلب بجامعة الأزهر. من يناير ٢٠٢٠ إلى مارس ٢٠٢٢. شمل البحث ٤٠ مريضاً يعانون من ضيق شديد بالصمام الأورطى. وقد تم إجراء الجراحة فى وحدات جراحة القلب والصدر بكلية الطب، جامعة الأزهر.

النتائج : باستثناء LVDEV، لم يكن هناك تغيير ملحوظ فى بيانات تخطيط صدى القلب بعد أسبوع واحد من استبدال الصمام الأورطى جراحياً. كان تغيير كبير فى بيانات تخطيط صدى القلب عند خط الأساس بعد شهر واحد، باستثناء LEF و GCS باستثناء LVEF، كان هناك تغيير كبير فى بيانات تخطيط صدى القلب فى ٣ أشهر.

الخلاصة : الاسترداد المبكر لوظيفة البطين الأيسر الطولية يشار إليه بالتحسن فى GLS الملحوظ بعد ٣ أشهر من إستبدال الصمام الأورطى جراحياً، على الرغم من عدم وجود تغيير جوهرى فى كفاءة عضلة القلب.