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Implications of Procedure of Thoracic Endovascular Aortic Repair on Left Ventricular Global Longitudinal Strain

Torasik Endovasküler Aort Onarımı Prosedürünün Sol Ventrikül Global Longitudinal Strain Üzerine Etkisi

ORIGINAL ARTICLE
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ABSTRACT

Objective: The aorta, particularly in its proximal segments, expands during systole to store blood, which is subsequently released into the peripheral circulation during diastole, morphologically and histologically. This function, referred to as the "Windkessel effect," ensures continuous and regular blood flow in the peripheral circulation. Thoracic Endovascular Aortic Repair (TEVAR) was introduced in the literature as a treatment for Type B aortic dissections (TBAD). In patients who undergo TEVAR, the placement of a stent graft in the proximal segments of the aorta, which are responsible for the highest capacity of blood storage and elasticity, may disrupt this function. Consequently, this alteration may lead to increased afterload and, over the long term, impair left ventricular systolic function. Previous studies have demonstrated that measurements of left ventricular global longitudinal strain (LVGLS) can detect early systolic dysfunction before any significant changes in left ventricular ejection fraction (LVEF) occur. The aim of this study was to compare preoperative and postoperative LVGLS measurements in patients who underwent TEVAR, thereby illustrating changes in LVGLS associated with the procedure.

Method: Patients who underwent TEVAR for TBAD or Thoracic Aortic Aneurysm (TAA) were included in the study. Patients with malignancy, advanced valvular pathology, end-stage chronic kidney disease, liver failure or heart failure, were excluded. Preoperative data, including comorbidities, medication use, blood parameters, electrocardiography findings, transthoracic echocardiography images and LVGLS values, were recorded. These parameters were then compared with the values obtained at the postoperative three-month outpatient follow-up.

Results: After the TEVAR procedure, a significant decrease in LVGLS was observed ($P < 0.001$). A strong correlation was found between the change in mean arterial pressure (MAP) and the reduction in LVGLS ($P = 0.555$, $P = 0.017$). Postoperatively, significant increases were noted in systolic blood pressure (SBP) and MAP (both $P < 0.001$). No significant differences were observed in other parameters, before and after the procedure.

Conclusion: In our study, a significant increase in SBP and MAP, along with a notable decrease in LVGLS values, were observed following the TEVAR procedure. A significant and strong correlation was identified between the increase in MAP and the decrease in LVGLS.

Keywords: Aortic compliance, global longitudinal strain, thoracic endovascular aortic repair, Windkessel effect

ÖZET

Amaç: Aort, özellikle proksimal segmentlerinde, sistol sırasında genişleyerek kanı depolar ve diyastol sırasında bu kanı periferik dolaşıma iletir. Bu morfolojik ve histolojik özellik "Windkessel etkisi" olarak adlandırılan bu fonksiyon periferik dolaşımda sürekli ve düzenli kan akışını sağlar. Tip B aort diseksiyonlarının (TBAD) tedavisi için literatüre Torasik Endovasküler Aort Onarımı (TEVAR) yöntemi girmiştir. TEVAR uygulanan hastalarda, kan depolama kapasitesi ve kompliyansı en yüksek olan proksimal aort segmentlerine stent greft yerleştirilmesi bu fonksiyonu bozabilir. Bu değişiklik, artmış ard yük ile sonuçlanarak uzun vadede sol ventrikül sistolik fonksiyonlarını olumsuz etkileyebilir. Önceki çalışmalar, sol ventrikül ejeksiyon fraksiyonunda (LVEF) belirgin bir değişiklik olmadan önce, sol ventrikül global longitudinal strain (LVGLS) ölçümlerinin erken sistolik disfonksiyonu tespit edebildiğini göstermiştir. Bu çalışmanın amacı, TEVAR uygulanan hastalarda preoperatif ve postoperatif LVGLS ölçümlerini karşılaştırarak, prosedüre bağlı olarak LVGLS'de meydana gelen değişiklikleri ortaya koymaktır.

Yöntem: Çalışmaya TBAD veya Torasik Aort Anevrizması (TAA) nedeniyle TEVAR uygulanmış hastalar dahil edilmiştir. Malignite, ileri derecede kapak hastalığı, son evre kronik böbrek yetmezliği, karaciğer yetmezliği veya kalp yetmezliği bulunan hastalar çalışma dışı bırakılmıştır.

Hastaların preoperatif döneme ait komorbiditeleri, ilaç kullanımları, kan parametreleri, elektrokardiyografi bulguları, transtorasik ekokardiyografi görüntüleri ve LVGLS değerleri kaydedilmiştir. Bu parametreler, postoperatif 3. ay poliklinik kontrollerinde elde edilen verilerle karşılaştırılmıştır.

Bulgular: TEVAR işlemi sonrası LVGLS'de anlamlı bir azalma gözlenmiştir (P < 0.001). Ortalama arter basıncındaki (OAB) değişim ile LVGLS azalması arasında güçlü bir korelasyon saptanmıştır (P = 0.555, P = 0.017). Postoperatif dönemde sistolik kan basıncı (SKB) ve OAB değerlerinde belirgin artış tespit edilmiştir (her ikisi için P < 0.001). İşlem öncesi ve sonrası diğer parametrelerde anlamlı bir fark bulunmamıştır.

Sonuç: Çalışmamızda, TEVAR işlemi sonrasında SKB ve OAB'de belirgin bir artış ile birlikte LVGLS değerlerinde anlamlı bir azalma saptanmıştır. Ayrıca, OAB artışı ile LVGLS azalması arasında güçlü ve anlamlı bir ilişki olduğu gösterilmiştir.

Anahtar Kelimeler: Aort kompliansı, global longitudinal strain, torasik endovasküler aort onarımı, Windkessel etkisi

Thoracic endovascular aortic repair (TEVAR) has been introduced as interventional treatment to the literature and is a well-established procedural technique for the management of type B aortic dissection.[1,2] Despite improvements in technology and techniques, including enhancements in biomedical graft materials, imaging techniques, implantation and procedural techniques, stent - graft implantation to the aorta increases stiffness of the aorta.[3] One study demonstrated that TEVAR has this effect and leads to myocardial dysfunction in young patients who underwent TEVAR as the result of a blunt thoracic aortic injury, in the previous five years.[4] Moreover, it has been showed that using endografts with different types of fabrics in endovascular aortic repair (EVAR) procedure, also resulted in increased aortic stiffness.[5] Another study confirmed this finding and showed that endograft implantation during EVAR procedure to the aorta increases the stiffness of aorta, when compared to open surgical repair.[6] In an experimental study on porcine model, researchers showed that implantation of endograft during TEVAR procedure to the aorta decreased the strain of aorta.[7] Based on these studies, we can see that there is limited knowledge about the potential effects of these grafts on aortic stiffness and their impact on heart function. Thus the effects of increased arterial stiffness after EVAR and TEVAR on the heart and the central hemodynamic, as well as an eventual effect on cardiac systolic function, need to be further investigated and evaluated.[8,9]

ABBREVIATIONS

2D STE	Two-dimensional speckle-tracking echocardiography
COPD	Chronic obstructive pulmonary disease
DM	Diabetes mellitus
ECG	Electrocardiography
EVAR	Endovascular aortic repair
HT	Hypertension
LA	Left atrial
LV	Left ventricle
LVEF	Left ventricular ejection fraction
LVGLS	Left ventricular global longitudinal strain
MAP	Mean arterial pressure
MRI	Magnetic resonance imaging
NT-pro BNP	N-terminal pro-Brain Natriuretic Peptide
PTFE	Polytetrafluoroethylene
RV	Right ventricle
RV GLS	RV global longitudinal strain
SBP	Systolic blood pressure
TAA	Thoracic Aortic Aneurysm
TBAD	Type B aortic dissections
TDI	Tissue Doppler imaging
TEVAR	Thoracic Endovascular Aortic Repair

Arterial stiffness has been closely associated with myocardial function, and left ventricular global longitudinal strain (LVGLS) is a powerful method in identifying left ventricular (LV) function.[10,11] Papadopoulos et al.[12] published one of the first case reports, when they investigated the changes in LVGLS after EVAR procedure in a patient and found that none of the echocardiographic parameters were deteriorated after the procedure, except for LVGLS. In their next study, they found that LVGLS deteriorated even in the early post-procedural follow up of these patients, after the EVAR procedure.[13] In order to address these questions, we designed this study with the aim to investigate the possible hemodynamic and LVGLS changes after the procedure of TEVAR and the possible changes associated with aortic stiffness.

Materials and Methods

Study Population and Demographics

Our study was performed with a prospective cohort and eighteen patients were included. It was conducted following the ethical approval by the Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training Research Hospital Ethical Committee (Approval Number: 2023.01-81, Date: 24.10.2023), between March 2023 and May 2024, in a tertiary referral hospital.

Patients over the age of eighteen who underwent the TEVAR procedure and provided their informed consent, were included in the study. Patients with left ventricular ejection fraction (LVEF) < 35%, or moderate to severe valvular heart disease, or patients with end stage kidney disease or with diagnosis of malignancy, were excluded from the study. It was conducted in accordance with the Declaration of Helsinki and no AI-assisted technology was used at any stage.

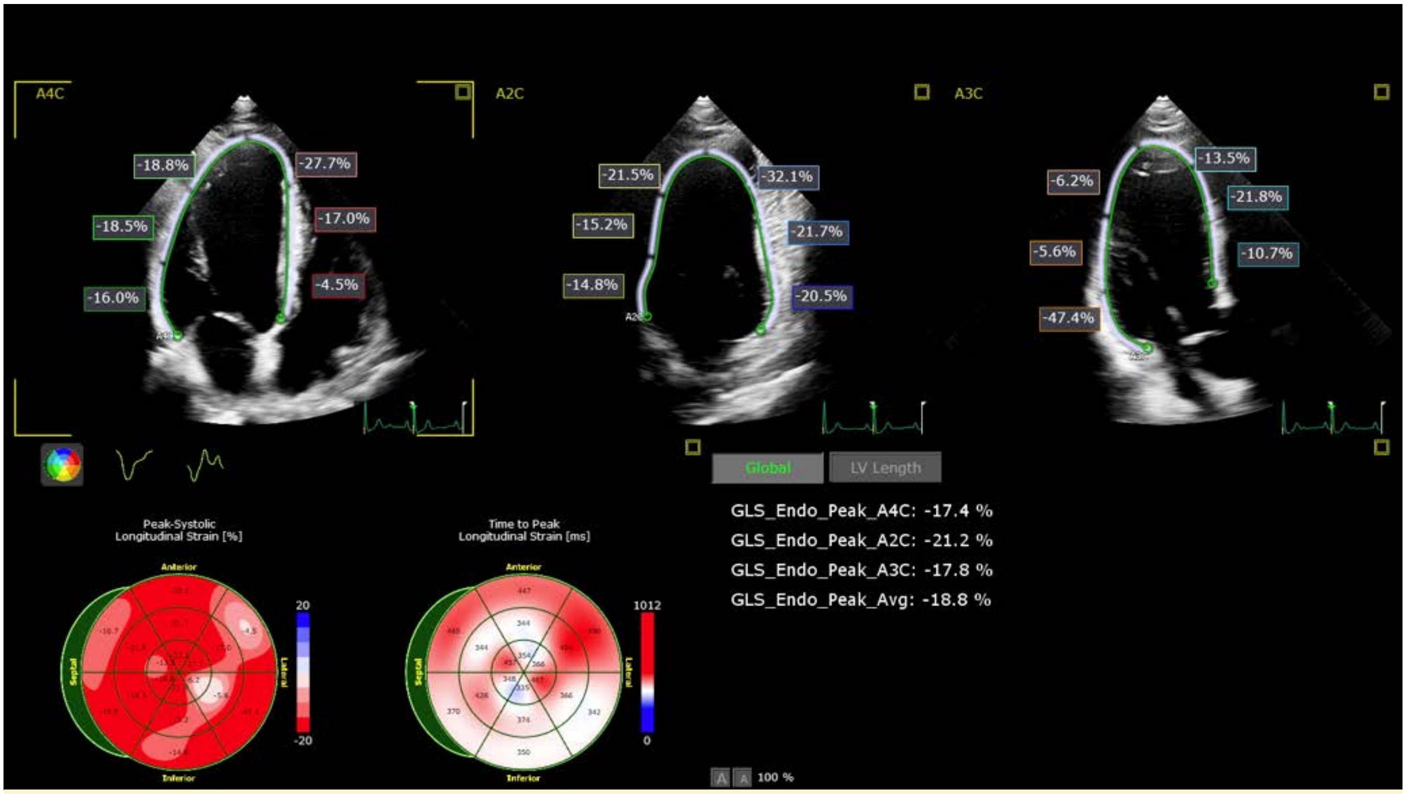

Figure 1. Left ventricular global longitudinal strain analysis using speckle-tracking echocardiography.

The demographic data, preoperative medication use, comorbid conditions, laboratory results and both electrocardiography (ECG) and echocardiographic measurements of the enrolled patients, were documented. Data including age, gender, presence of comorbid diseases such as hypertension (HT), hyperlipidemia, diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), kidney disease (not an end-staged) and cerebrovascular disease, were noted for all the patients. ECG recordings were evaluated including heart rate, presence of branch blockage, PR and QRS duration. Laboratory tests included complete blood count, creatinine and N-terminal pro-Brain Natriuretic Peptide (NT-pro BNP). The blood pressure values measured after the patients were rested, prior to the TEVAR procedure, were recorded in the patient's file, along with the recorded ECG and variables of transthoracic echocardiogram. Upon the patient's three-month follow-up visit, the same values were documented.

Echocardiographic Evaluation

The echocardiographic images of all participants were acquired using a Philips EPIQ CVX 3D system (Philips Healthcare, Andover, MA, USA), an S5-1 transducer (3.5 MHz) for 2-Dimensional (2D) measurements and an X5-1 transducer (1-3 MHz) for 3-Dimensional (3D) measurements. Echocardiographic data included both conventional parameters and strain parameters. Standard M-mode, 2D, Doppler and color-coded tissue Doppler (TDI) images were obtained during breath hold, stored in cine loop format from three consecutive beats, then transferred to a workstation for further offline analysis. Conventional echocardiographic measurements were performed in accordance with the recommendations of the European Association of Cardiovascular Imaging guidelines.[14] LV, right ventricular (RV) and left atrial (LA) strains were measured for every patient, as described in previous studies.[15–17] The evaluation of LVGLS was conducted using two-dimensional speckle-tracking echocardiography (2D STE), with imaging obtained from the apical two-chamber, three-chamber and four-chamber views of the LV. In each of these apical views, the LV was subdivided into six segments. The LVGLS value was calculated as the average of the peak systolic longitudinal strain values from each of the six segments, across all apical views (Figure 1). The LA endocardial border was manually delineated in the apical four-chamber view, integrating the six segments. Following an analysis of the tracking quality for each segment, any necessary manual adjustments were made. Subsequently, strain curves for each atrial segment were generated using the software, which utilized the QRS complex (R-R gating) to initiate the strain calculation. With the use of the R wave, all strain values were recorded as positive. Two distinct peaks were observed: the first, occurring between the R wave and T wave, corresponded to the reservoir function, while the second peak, initiated by the P wave, reflected the atrial contractile function. The difference between the strain values of the reservoir and atrial contractile functions, provides an indication of the conduit function (Figure 2). The RV endocardial borders were traced and fine-tuned manually to ensure that the six segments (basal, middle and apical of the free wall and interventricular septum), were tracked appropriately and then time-strain curves generated for measurement of RV global longitudinal strain (RV GLS) (Figure 3).

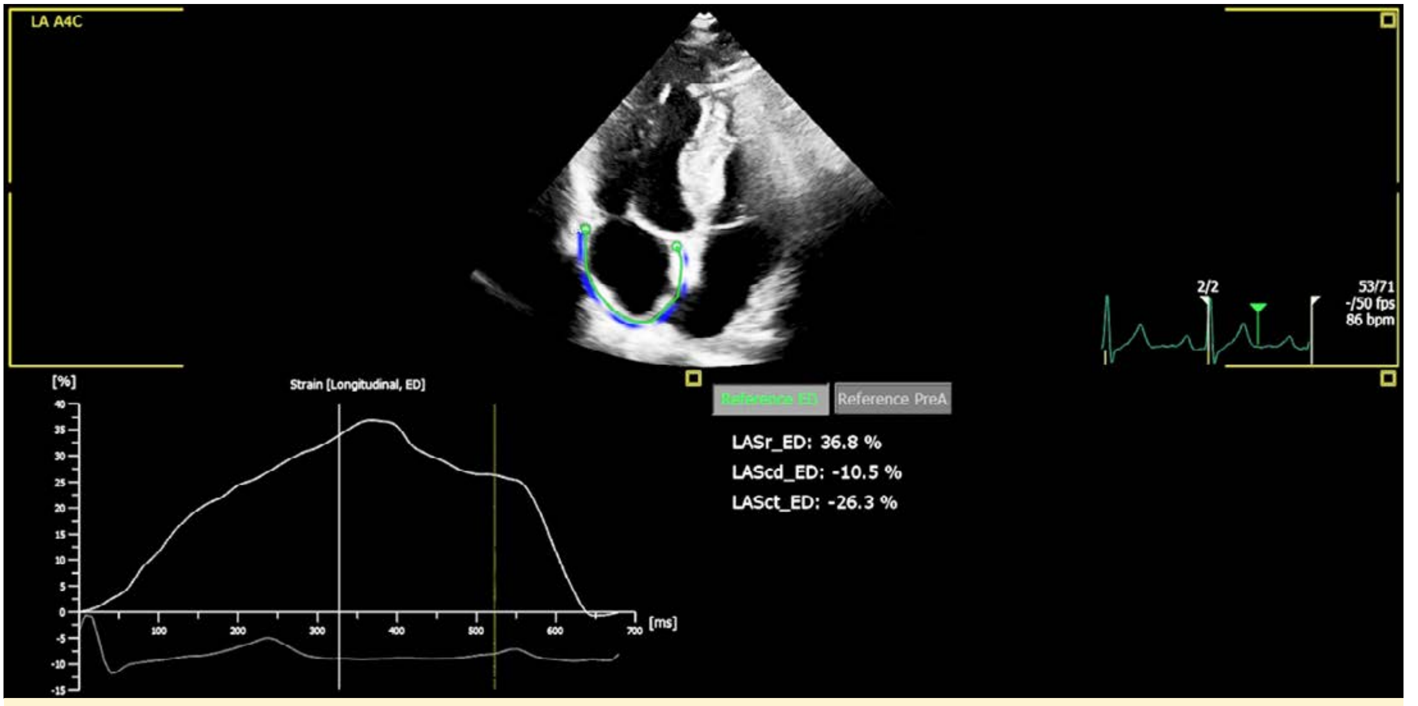

Figure 2. Assessment of left atrial conduit function.

Patients were routinely scheduled for a follow-up visit at the outpatient clinic, three months after the procedure. During this visit, laboratory results, ECG and echocardiographic measurements were reassessed and LVGLS, LA strain and RV GLS values were re-measured, using the same device.

Statistical Analysis

The statistical analysis of the study was conducted using the SPSS Version 27.0 (SPSS Inc., Chicago, Illinois, USA). As the number of patients included in the study was eighteen, numerical variables are presented as median (interquartile range), while categorical variables are expressed as percentages (%). The statistical analysis of numerical variables between groups, such as LVGLS, was performed using the Wilcoxon test and the analysis of categorical variables was conducted using the Mann-Whitney U test. The correlation of LVGLS with other numerical parameters was assessed using Spearman's analysis. The threshold for statistical significance was set at $P < 0.05$.

Results

A total of eighteen patients were included in the study. The median age of the patients was 56.0 years, with eleven of them being male. The demographic and clinical characteristics of the patients, along with their follow-up durations, are summarized in Table 1. Among the patients included in the study, thirteen patients had HT, one patient had DM, three patients had COPD and three patients had coronary artery disease.

Twelve patients (66.67%) were using at least one antihypertensive medication prior to the procedure, whereas after the procedure, sixteen patients (88.89%) were using at least one. The medications used by the patients before and after the procedure are summarized in Table 2.

Table 1. Demographic and clinical characteristic of the study group

Age, years	56.0 (45.5–61.0)
Follow up duration, (days)	107.5 (92.5–126.0)
Male sex, n (%)	11 (61.1)
Hypertension, n (%)	13 (72.2)
Diabetes mellitus, n (%)	1 (5.6)
Chronic obstructive pulmonary disease, n (%)	3 (16.7)
Coronary artery disease, n (%)	3 (16.7)

Table 2. Antihypertensive medication usage of the patients before and after the procedure

	Before procedure n (%)	After procedure n (%)
Angiotensin converting enzyme inhibitors	6 (33.3)	11 (61.1)
Angiotensin receptor blockers	4 (22.2)	3 (16.7)
Beta blockers	10 (55.6)	15 (83.3)
Calcium channel blockers	8 (44.4)	13 (72.2)

The association between clinical and demographic characteristics with LVGLS is shown in Table 3. There was no significant implication between demographics, clinical characteristics of the patients and change in LVGLS, after the procedure. When comparing the patients' medication use before and after the procedure with changes in LVGLS after the procedure, no significant difference was observed between the groups (Table 4).

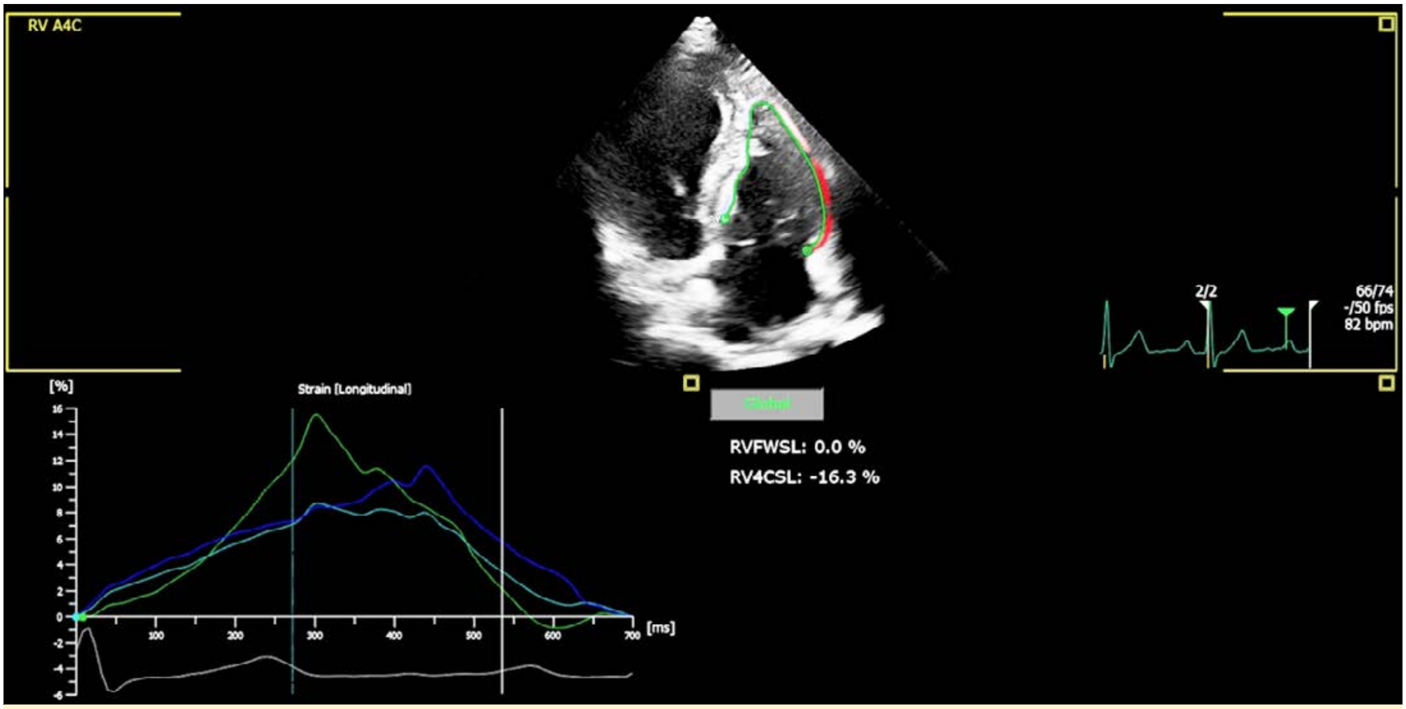

Figure 3. Right ventricular global longitudinal strain (RV GLS) measurement.

Table 3. The association between demographic and clinical characteristics of the patient group and change in left ventricular global longitudinal strain after the procedure

	Change in LVGLS	P
Gender		0.928
Male	1.90 (1.50–4.10)	
Female	2.10 (1.00–6.50)	
Hypertension		0.278
With diagnosis	1.90 (1.15–3.25)	
Without diagnosis	4.10 (1.75–4.50)	
Coronary artery disease		0.109
With diagnosis	1.50 (1.15–1.70)	
Without diagnosis	2.20 (1.70–4.20)	

LVGLS, Left ventricular global longitudinal strain.

Table 4. Change in LVGLS after the procedure in patients under antihypertensive medication and without antihypertensive medication before the procedure

	Change in LVGLS with medication usage	Change in LVGLS without medication usage	P
ACE-Inh	2.80 (1.32–6.50)	1.85 (1.40–3.82)	0.51
ARB	2.05 (1.45–2.80)	1.95 (1.37–4.35)	0.83
BB	1.80 (1.22–3.67)	2.15 (1.80–4.62)	0.35
CCB	1.70 (1.07–5.75)	2.15 (1.77–4.12)	0.66

ACE-inh, Angiotensin converting enzyme inhibitors; ARB, Angiotensin receptor blockers; BB, beta blockers; CCB, Calcium channel blockers; LVGLS, Left ventricular global longitudinal strain.

The evaluation of ECG recordings and data about blood pressures are summarized in Table 5. No significant difference was observed before and after the procedure regarding heart rate, PR interval and QRS duration on the ECG recordings. Four patients who were not using antihypertensive medication before the procedure were started on antihypertensive treatment, and the antihypertensive therapy of five patients was increased after the procedure. Despite this, a significant increase was observed in the patients' systolic blood pressure and non-invasive mean arterial pressure values post-procedure, compared to pre-procedure values ($P < 0.001$ for both analyses). No significant difference was observed in diastolic blood pressure values before and after the procedure ($P = 0.432$).

The statistical evaluation of the laboratory parameters is shown in Table 6. No significant difference was observed between the laboratory parameters assessed before the procedure and those re-evaluated during the three-month follow-up visit.

The statistical evaluation of the TTE parameters is shown in Table 7. The TTE images obtained before the procedure and those obtained during the three-month follow-up visit were compared. The analysis showed that the LVGLS value after the procedure was significantly lower, compared to pre-procedure values ($P < 0.001$). No significant changes were observed in other TTE parameters. The correlation between the change in LVGLS before and after the procedure and other parameters was evaluated. A significant positive correlation was observed between the change in mean arterial pressure and the change in LVGLS (Figure 4, $P = 0.555$, $P = 0.017$). No significant correlation was found between the change in LVGLS and other parameters.

Table 5. Comparison of ECG parameters and blood pressure measurements before and after the procedure

	Pre-procedural	Post-procedural	P
Heart rate, bpm	73.00 (69.75–86.00)	79.00 (66.75–83.50)	0.896
PR duration, ms	156.00 (146.50–178.50)	152.00 (141.50–174.00)	0.169
QRS duration, ms	88.00 (81.50–98.50)	87.00 (81.50–92.00)	0.142
Systolic blood pressure, mmHg	114.50 (108.75–128.25)	155.00 (146.50–168.00)	< 0.001
Diastolic blood pressure, mmHg	72.00 (64.25–81.50)	73.00 (65.00–85.00)	0.432
Mean arterial blood pressure, mmHg	87.83 (77.25–97.75)	99.50 (93.66–114.58)	< 0.001

ECG, Electrocardiography.

Table 6. Comparison of laboratory parameters before and after the procedure

	Before procedure	After procedure	P
Hemoglobin, g/dL	11.50 (9.90-12.52)	12.05 (10.20-12.92)	0.276
Leucocytes, /μL	8.09 (7.01-10.30)	7.90 (6.54-9.39)	0.327
Lymphocytes, /μL	1.84 (1.21-2.49)	1.95 (1.48-2.52)	0.463
Neutrophils, /μL	5.36 (4.64-7.39)	4.86 (3.72-6.10)	0.193
Glucose, mg/dL	108.00 (90.50-122.00)	106.50 (88.00-132.25)	0.943
Albumin, g/dL	4.12 (3.62-4.22)	4.13 (3.79-4.41)	0.410
Creatinine, mg/dL	0.98 (0.88-1.26)	0.98 (0.84-1.12)	0.472
Glomerular filtration rate, mL/dk/1,73m^2	71.78 (55.12-97.39)	82.75 (57.18-94.77)	0.711
C-reactive protein, mg/dL	26.25 (6.87-84.25)	15.25 (6.72-34.25)	0.306
Brain natriuretic peptide, pg/mL	231.65 (125.57-1010.52)	177.80 (79.01-577.47)	0.600

Table 7. The comparison of echocardiographic parameters before and after the procedure

	Pre-procedural	Post-procedural	P
Ejection fraction	60.00 (60.00-60.00)	60.00 (60.00-60.00)	0.317
Left ventricular end diastolic diameter	47.50 (45.75-50.00)	48.00 (46.00-52.00)	0.166
Left ventricular end systolic diameter	31.00 (28.75-34.25)	32.00 (30.75-33.25)	0.327
Left atrial diameter	37.50 (34.50-38.25)	37.00 (35.00-39.00)	0.894
Diameter of ascending aorta	36.95 (34.15-39.77)	37.50 (35.70-39.75)	0.593
Diameter of sinus of valsalva	36.30 (33.75-39.50)	36.00 (33.90-39.70)	0.434
TAPSE	22.35 (20.62-25.15)	21.85 (17.95-24.00)	0.133
Tricuspid annular S wave velocity	13.75 (12.27-15.67)	13.10 (11.15-16.20)	0.177
E wave velocity	71.00 (57.75-89.25)	70.50 (57.00-84.25)	0.316
A wave velocity	84.50 (78.00-98.00)	85.00 (72.50-91.00)	0.157
Septal E wave velocity	5.65 (4.59-6.25)	5.15 (4.65-5.40)	0.080
Lateral E wave velocity	7.66 (7.10-9.95)	7.85 (7.27-8.72)	0.446
Left ventricular global longitudinal strain	-15.50 (-17.40,-14.25)	-13.00 (-15.20,-11.30)	< 0.001
Left atrium strain	20.20 (14.30-37.37)	22.00 (14.87-30.27)	0.948
Right ventricular free-wall strain	-16.60 (-18.00,-14.80)	-14.90 (-17.55,-11.00)	0.053

TAPSE, Tricuspid annular plane systolic excursion.

Discussion

Our study investigated the possible changes in strain of the heart after endograft implantation to aorta, via the TEVAR procedure. Our study showed that endograft implantation to the aorta increased systolic blood pressures, however it did not change diastolic blood pressures after the TEVAR procedure. Moreover, due to the change in afterload and compliance of the aorta, LV functions were also affected after the graft implantation independent of LVEF and our study showed that LVGLS were significantly reduced, after endograft implantation to the aorta. The change in LVGLS were not found to be associated with other morbidities or aging in the study group, which indicates that the procedural change in aorta was associated with the change of LVGLS.

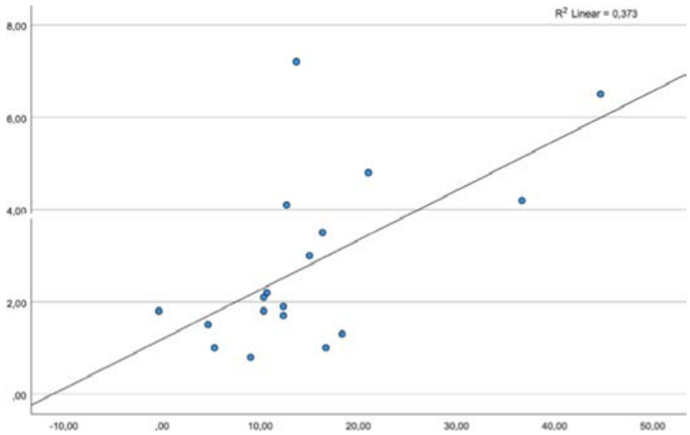

Figure 4. Correlation between change in mean arterial pressure (MAP) and change in left ventricular global longitudinal strain (LVGLS) following the procedure.

It is well known that aortic stents might implicate the compliance of the aorta. Agrafiotis et al.[18] studied thoracic aortic stents in ten patients as ex-vivo and their experiment showed that aortic distensibility was significantly reduced after TEVAR, and caused aortic stiffening and mismatch in the compliance of aorta. In another study, Kadoglou et al.[5] conducted a study, between April 2010 and November 2011, involving 118 patients who underwent abdominal EVAR. The study aimed to compare the outcomes of stent grafts coated with polytetrafluoroethylene (PTFE) and polyester. In this study, 46 patients received PTFE-coated stent grafts, while 72 patients received polyester-coated stent grafts. The assessment of aortic stiffness was performed using pulsed wave velocity in the aorta. The results of the study showed an increase in aortic stiffness when comparing preoperative and postoperative measurements, whereas the comparison between the two types of stent grafts showed no significant difference. Based on these findings, it was concluded that aortic stiffness increased after EVAR, independent of the type of the grafts used. In another study, Rong et al.[19] showed that aortic circumferential strain and stiffness increased after graft implantation to the aorta. These studies illustrate the close relationship between aortic stenting and aorta compliance, emphasizing how stent implantation affects both the stiffness and compliance of the aorta.

These studies also concluded that endograft implantation leads to a reduction in aortic compliance. This decrease in compliance results in a diminished Windkessel effect, which ultimately causes an increase in arterial stiffness. In previous studies, the increase in arterial stiffness was associated with a rise in systolic blood pressure and a decrease in diastolic blood pressure.[20,21] In our study, systolic blood pressure values were found to be 114.50 (108.75 - 128.25) mmHg before the procedure and 155.00 (146.50 - 168.00) mmHg after the procedure. The mean arterial pressure was 87.83 (77.25 - 97.75) mmHg before the procedure and 99.50 (93.66 - 114.58) mmHg after the procedure. There was a significant increase in both systolic blood pressure and mean arterial pressure after the procedure ($P < 0.001$ for both analyses). No significant change was observed in diastolic blood pressure values ($P = 0.432$). Our results are consistent with the expected outcomes of increased arterial stiffness due to the reduction in aortic compliance.

The reduction in aortic compliance not only affects peripheral circulation and blood pressures but also impacts the increased afterload on LV function. Studies suggest that an increase in afterload may lead to impaired LV function.[22] Impairment of LV function can be detected early with LVGLS, even before changes in LVEF are apparent. Aside from hypokinesis due to ischemic heart disease, LVGLS is also affected by increased afterload from other conditions, making it more effective than LVEF in predicting long-term outcomes.[23,24] In our study, no significant change was observed in LVEF before the procedure and after a median follow-up of 107.5 days. However, LVGLS values were -15.50 (-17.40, -14.25) before the procedure and -13.00 (-15.20, -11.30) after the procedure, and a significant decrease in LVGLS was observed after the procedure. It has been previously demonstrated that EVAR might lead to decrease in LV functions and deterioration of LVGLS after the procedure. Marketou et al.[13] studied the change of LVGLS after EVAR and showed a significant decrease in LVGLS values between baseline and the six-month follow-up, in patients who underwent EVAR. In the same study, no significant changes were observed in systolic blood pressure, diastolic blood pressure or pulse pressure. And the need for better prosthetic materials and improvement in endograft materials has been suggested for EVAR in previous articles.[25] However, the information about the implication of implantation of endograft with TEVAR to the aorta is limited. Ghazy et al.[4] conducted a study that is analogous and correlative to ours, between 2009 and 2019, for which they evaluated ten patients who underwent TEVAR for blunt thoracic aortic trauma and a control group of ten healthy individuals, using cardiac magnetic resonance imaging (MRI). The study reported that in the TEVAR group, the 3D diastolic LV longitudinal strain ratio and velocities were significantly lower, compared to the control group. The authors attributed this result to the increased arterial stiffness, which primarily impairs the transmission of blood that should be delivered to the periphery during diastolic relaxation. This is, again, due to a reduction in the Windkessel function, leading to an increased afterload. However, their study was conducted using cardiac MRI: ours is distinctive in that it specifically examined LVGLS using echocardiography in patients who underwent TEVAR. Our results were consistent with those observed in research involving EVAR, however it is valuable to note that TEVAR involves the placement of endografts in the proximal portion of the aorta, while EVAR typically involves the implantation of endografts in the distal aorta. We hypothesize that the implantation of TEVAR grafts in the proximal aorta may have a more pronounced effect on the Windkessel effect, as this region plays a key role in the regulation of arterial compliance and afterload, potentially leading to greater alterations compared to EVAR.

Study Limitations

The patients' blood pressure measurements were performed as single office measurements, prior to the echocardiographic examination. Since LVGLS measurement is afterload-dependent, the decrease in LVGLS may not be directly associated with impairment of LV systolic function. It would be more accurate to repeat the measurements after the patients become normotensive, or to reach a conclusion based on the average blood pressure obtained through 24-hour monitoring.

In the patients participating in the study, body surface area and body mass index were not evaluated and it is known that these parameters have an effect on arterial blood pressure. Evaluating the changes in indexed aortic measurements according to these parameters, along with the decrease in LVGLS and arterial blood pressure, may provide us with a more comprehensive view to understand the possible hemodynamic effects of the TEVAR procedure.

Our study was a single-center observational study and due to the limited sample size of eighteen patients, a detailed analysis of the TEVAR procedure could not be performed. Evaluations based on larger sample sizes, including factors such as procedure duration, the region of the aorta where the endograft is implanted and the length of the endograft, may help us better understand the hemodynamic changes and remodelling process associated with TEVAR.

Conclusion

Our study suggests that implantation of endograft to the proximal aorta with TEVAR procedure, may lead to increased stiffness and may implicate with the afterload which affects LV functions. As decrease in LVGLS is a strong predictor of adverse cardiovascular outcomes, based on the results of this study, therefore we recommend that patients who undergo TEVAR should be closely monitored postoperatively with regular blood pressure checks and intermittent LVGLS measurements. This approach could facilitate the close monitoring of LV function and may help prevent cardiovascular mortality.

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