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Speckle Tracking Echocardiography: The Secret Key To Predicting Poor Outcomes in Infective Endocarditis

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SOUHRN

Cíle: Určit úlohu speckle tracking echokardiografie při zjišťování subklinické dysfunkce myokardu u pacientů s infekční endokarditidou (IE) a predikovat jejich výsledný stav v nemocnici.
Metody: Do studie jsme prospektivně zařadili 46 pacientů s aktivní IE. Byla provedena kultivace krevních vzorků a sérologické vyšetření, krevní vzorky byly odebírány opakovaně pro stanovení celkového počtu leukocytů a hodnot C-reaktivního proteinu (CRP) a prokalcitoninu. Opakovaně bylo provedeno i klasické transtorakální speckle tracking echokardiografické vyšetření.
Výsledky: U většiny pacientů byla diagnostikována pravostranná IE přičítaná intravenózní aplikaci omamných látek. Přes zachovanou ejekční frakci levé komory (EF LK) vykazovali všichni pacienti při příjmu celkovou longitudinální deformaci (global longitudinal strain, GLS). Nepříznivé výsledky korelovaly se statisticky méně negativní hodnotou GLS (p < 0,001) a infekcí MRSA (p = 0,043). Hodnota GLS při příjmu korelovala s hodnotami CRP a prokalcitoninu i velikostí vegetace. Vyšší procenta zlepšení hodnot v případě prokalcitoninu, velikosti vegetace i GLS byly pozorovány u pacientů s příznivým výsledným stavem (p < 0,001). Hodnoty GLS (p = 0,016; OR 28,97) a velikost vegetace (p = 0,029; OR 4,41) byly statisticky významnými prediktory nepříznivého výsledku léčby. Mezní hodnota GLS ≥ −14,5 % predikovala nepříznivý výsledný stav se středně vysokou senzitivitou (76 %) a specificitou (65 %) (AUC 0,75; p = 0,002).
Závěr: Subklinická myokardiální dysfunkce při sepsi, zjištěná na základě hodnoty GLS, se u pacientů s IE vyskytuje často, zvláště u pacientů s komplikovaným průběhem onemocnění v nemocnici. Hodnoty GLS a velikost vegetace při příjmu nezávisle predikují nepříznivý výsledek léčby. Hodnota GLS LK > −14,5 % může se středně vysokou pravděpodobností předpovídat komplikace během hospitalizace.

Keywords:
Global longitudinal strain
Infective endocarditis
Speckle tracking echocardiography

ABSTRACT

Objectives: To investigate speckle-tracking echocardiography's role in detecting subclinical myocardial dysfunction in infective endocarditis (IE) patients and predicting in-hospital outcomes.
Methods: We prospectively enrolled 46 patients with active IE. Blood cultures and serology tests were performed, and blood samples for total leucocytic count, C-reactive protein (CRP), and procalcitonin were collected at multiple intervals. Serial conventional transthoracic echocardiography with speckle tracking was also performed.
Results: Most patients had right-sided IE linked to intravenous drug use. Despite preserved left ventricular ejection fraction (LVEF), all patients showed impaired global longitudinal strain (GLS) on admission. Poor outcomes correlated with significantly less negative GLS (p <0.001) and MRSA infection (p = 0.043). GLS on admission correlated with CRP, procalcitonin, and vegetation size. Higher improvement rates in procalcitonin, vegetation size, and GLS were seen in patients with favorable outcomes (p <0.001). GLS (p = 0.016, OR 28.97) and vegetation number (p = 0.029, OR 4.41) were significant predictors of poor outcomes. A GLS cut-off ≥−14.5% predicted poor outcomes with moderate sensitivity (76%) and specificity (65%) (AUC 0.75, p = 0.002).
Conclusion: Subclinical myocardial depression detected by GLS is common in IE patients, particularly those with complicated hospital courses. GLS and vegetation number on admission independently predict poor outcomes. An LV GLS >−14.5% can moderately predict in-hospital complications.

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Introduction

Infective endocarditis (IE) is a heterogeneous disease with high complication and mortality rates. The prognosis depends on existing comorbidities, the presence of cardiac devices or valvular prosthesis, and the virulence of the causative microorganism.[1]

Left ventricular (LV) function is a powerful predictor of outcomes in patients with infectious diseases and sepsis. However, limitations exist in using LV ejection fraction (EF) to characterize systolic function – geometric assumptions, technical issues such as apical foreshortening, and dependence on loading conditions.[2]

Strain-imaging by 2D speckle-tracking echocardiography (2D-STE) has clinical utility in a variety of settings and offers superior prognostic value over EF for predicting major adverse cardiac events. Advantages of using global longitudinal strain (GLS) to assess LV systolic function over EF include better reproducibility, ability to identify subclinical LV dysfunction, non-reliance on geometric assumptions, and lack of influence by tethering effects.[3]

Patients and methods

This prospective study included patients referred to the IE working group at Kasr Alaini Cardiovascular Department between July 2019 and December 2021.

Inclusion criteria

- Patients with definitive uncomplicated IE diagnosis according to the ESC guidelines 2015.[4]
- Patients who were destined for medical treatment only.
- Patients with normal baseline LV EF by conventional 2D trans-thoracic echocardiography (TTE).
- Patients with high-quality images.

Exclusion criteria

- **Patients with IE presenting with an indication for urgent or emergent surgery.**

At least three sets of blood cultures were withdrawn from all patients before starting antibiotics –with the first and last samples drawn at least 1 hour apart. Serology tests were done for *Coxiella burnetii*, *Bartonella* species, *Brucella* species, *Legionella pneumoniae*, and *Aspergillus* species. We recorded different markers of inflammation and infection on admission and during the hospital course, to monitor treatment response, including total leucocytic count (TLC), C-reactive protein (CRP), and procalcitonin.

A comprehensive 2D transthoracic echocardiography was performed within 24 hours of admission using Affiniti Philips (Philips Medical Systems, Andover, MA, USA) equipped with 1–5 MHz X5-1 transducer. All measurements were calculated according to the American Society of Echocardiography and the European Association of Cardiovascular Imaging recommendations.[5] LVEF was calculated by the modified Simpson's biplane method. IE-related data including vegetation (an echogenic mass on the endocardium or intracardiac prosthesis with independent oscillating motion), and their related site, size, number and related valvular lesions were recorded.

For the 2D-STE image acquisition, sector size, and depth were adjusted to achieve optimal visualization of all LV myocardium in the three standard apical views (4-, 2-, and long-axis view) and parasternal short axis (basal, mid, and apical levels) at a frame rate between 60 and 100 fps. Images of three consecutive cardiac cycles were stored digitally for offline analysis with QLab 10 software (cardiac motion quantification (CMQ); Philips Medical Systems). The stored grayscale images were analyzed offline to measure LV deformation performance. Each of the apical or short-axis views was divided into 6 segments. The GLS and global circumferential strain (GCS) were averaged from the total 17 segments –the normal value for GLS is <–20%.[5]

Patients were divided into two groups according to their hospital course and clinical outcome. The first group included patients with favorable hospital course and outcomes (i.e., good clinical and laboratory responses to medical treatment defined as subsiding fever with improvement in laboratory markers of infection and inflammation in the absence of in-hospital complications). The second group included those with poor hospital course or outcome (defined as death caused primarily by uncontrolled infection or the occurrence of complications during the hospital course that are directly related to the uncontrolled infection such as NYHA class III–IV heart failure, systemic or pulmonary embolization, or uncontrolled infection –persistent fever for > 7–10 days despite proper antibiotic regimen after excluding extra-cardiac or other causes of fever).[4]

Follow-up

All patients had repeated TTE studies to follow up on the previously mentioned echocardiographic parameters at the following pre-specified timings after initiating the antibiotic course: 7–10 days, 14–21 days, and predischarge. This was paralleled with monitoring temperature and laboratory markers of infection, as well as recording any developing complications during the hospital stay. Patients who developed in-hospital complications, that prompted altering their management strategy to urgent intervention, had additional pre-operative TTE and 2D STE studies.

Informed consent was obtained from all the participants. The study was approved by our University's Ethics Committee in July 2019 (MD-56-19).

Statistical analysis

The data were tested for normality. Continuous variables were presented as mean ± SD for normally distributed data and median, interquartile range (IQR) for skewed data. Categorical data were presented as numbers (%). Comparison between groups was done using Chi-square and Fischer's exact tests for categorical data and t-test / Wilcoxon-Sign test for numerical variables (in normal and skewed data respectively). Repeated measurement analysis was done for all continuous variables that had serial measurements. Significant variables in the univariate analysis were categorized into clinical, laboratory, and echocardiographic groups, and were entered separately in a multivariate logistic regression analysis to detect the most significant predictors of poor outcomes. The Receiver Operator Characteristics (ROC) curve was plotted to detect the cut-off point of GLS at which bad outcomes significantly increased. Scatter plots were examined between GLS and all significant continuous variables to detect any correlation, *p* values were considered significant at <0.05.

Results

Among 55 patients, 49 patients met eligibility for our study (four patients were excluded due to acute nephritic syndrome diagnosis, and two patients had a suboptimal image quality for strain analysis). Three patients were discharged against medical advice, ending with 46 patients.

Patients with favorable in-hospital outcomes were 24 patients (52.2%) while those with poor outcomes were 22 (47.8%). Poor outcomes included: lack of response to medical treatment (14 patients,30.4%), pulmonary embolism (21 patients, 45.7%), heart failure (1 patient, 2.2%), and death (5 patients, 10.9%).

Baseline clinical parameters associated with poor outcomes are presented in **Table 1** and include procalcitonin level, severity of valve incompetence, size, and number of vegetations, and MRSA infection.

Baseline speckle tracking echocardiography data

Right-sided infective endocarditis was present in 93.5% of patients, so the tricuspid valve affection predominated.

Table 1 – Baseline patients' data

	All patients (n = 46)	Favorable outcome (n = 24)	Poor outcome (n = 22)	*p*-value
Demographics				
Age, years	31.8 ± 6.15	32.8 ± 7.12	30.6 ± 4.81	0.24
Gender, male	37 (80.4%)	18 (75%)	19 (86.4%)	0.46
Risk factors				
IVDU	42 (91.3%)	20 (83.3%)	22 (100%)	0.13
RHD	1 (2.2%)	1 (4.2%)	–	
Valve prolapse	1 (2.2%)	1 (4.2%)	–	
Obstetric procedure	2 (4.3%)	2 (8.3%)	–	
Prior IE	1 (2.2%)	–	1 (4.5%)	
Comorbidities				
Diabetes mellitus	1 (2.2%)	1 (4.2%)	–	1.0
HCV positive	17 (37%)	5 (20.8%)	12 (54.5%)	**0.018**
Temperature on admission, °C	38.9 ± 0.67	38.62 ± 0.57	39.14 ± 0.64	**0.013**
Lab results				
TLC (10^3/mm^3)	16.1 ± 4.47	15.3 ± 3.98	16.96 ± 4.88	0.274
CRP (mg/dL)	170 ± 80.3	141.79 ± 65.6	200.59 ± 84.86	**0.019**
Procalcitonin (ng/ml)	2.2 ± 0.93	1.75 ± 0.66	2.7 ± 0.93	**<0.001**
TTE volumes				
LVEDV (ml)	106 ± 14.1	105.08 ± 16.48	105.95 ± 11.37	0.7
LVESV (ml)	41.7 ± 6.13	41.92 ± 6.45	41.5 ± 5.89	0.83
LVEF (%)	60.5 ± 3.57	61.04 ± 3.08	59 ± 4.04	0.23
Affected valves				
Tricuspid	40 (87%)	20 (83%)	20 (91%)	0.9
Mitral	4 (8.7%)	4 (16.7%)	–	1.0
Pulmonary	1 (2.2%)	–	1 (4.5%)	1.0
Mitral and tricuspid	1 (2.2%)	–	1 (4.5%)	1.0
Degree of valve incompetence				
Severe	32 (69.6%)	12 (50%)	20 (90.9%)	**0.003**
Moderate	14 (30.4%)	12 (50%)	2 (9.1%)	
Number of vegetations	1.6 ± 0.61	1.29 ± 0.46	1.95 ± 0.57	**<0.001**
Size of largest vegetation (mm)	25.2 ± 6.4	22.79 ± 6.07	27.77 ± 5.84	**0.006**
MRSA infection	22 (47.8%)	8 (3.3%)	14 (63.6%)	**0.04**
MSSA	7 (15.2%)	4 (16.7%)	3 (13.6%)	1.0
Negative	15 (32.6%)	11 (45.8%)	4 (18.2%)	**0.046**
Streptococci	1 (2.2%)	1 (4.2%)	–	1.0

Values are presented as mean ± SD and number (%). CRP – C-reactive protein; HCV – hepatitis C virus infection; IE – infective endocarditis; IVDU – intravenous drug use; LVEDV – left ventricular end-diastolic volume; LVEF – left ventricular ejection fraction; LVESV – left ventricular end-systolic volume; MRSA – methicillin-resistant *Staphylococcus aureus*; MSSA – methicillin-sensitive *Staphylococcus aureus*; RHD – rheumatic heart disease; TLC – total leucocytic count.

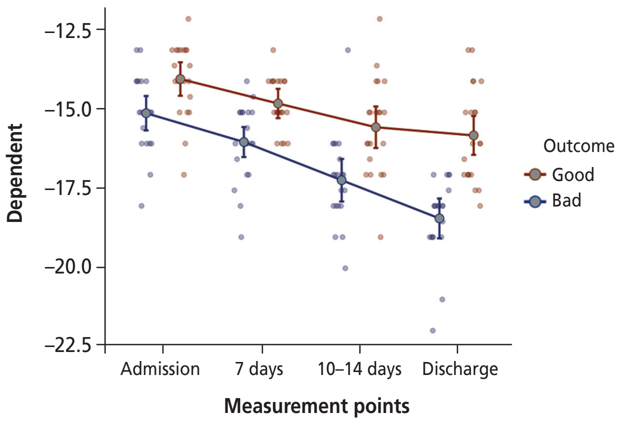

Fig. 1 – Global longitudinal strain (GLS) changes throughout the follow-up of the two groups of patients.

Though LVEF by 2D TTEE did not significantly differ between the two groups, the GLS, and speckle-derived LVEF on admission were significantly lower in patients who had poor outcomes (**Table 2**).

Follow-up data

Patients with favorable outcomes had a substantial decrease in vegetation size (p <0.001) and a faster pace of improvement in procalcitonin and GLS (p <0.001) (**Fig. 1**). GLS, GCS, and LVEF showed steady improvement in both groups during the hospital course (**Table 3**).

Variations in procalcitonin were the sole significant early differences between the two groups (p <0.001), as seen in **Table 4.**

Correlation between global longitudinal strain on admission and different parameters of infection

GLS on admission was significantly correlated with the largest vegetation size on admission and the temperature (p = 0.02 for both) (**Table 5**), as well as CRP and procalcitonin (p = 0.031 and p = 0.01, respectively), as shown in **Figure 2**.

Multi-variate regression analysis of the predictors of poor in-hospital outcome

Multivariate regression analysis was done using the significant clinical, laboratory, and echocardiographic variables on admission to identify the independent predictors of in-hospital complications and worse outcomes. Clinical (HCV infection, degree of valve incompetence, and temperature on admission) and laboratory variables (MRSA infection, negative cultures, ESR, CRP, and procalcitonin) did not show significant association with apoor outcome, while some echocardiographic variables (vegetation size and GLS) showed the most significant independent association (**Table 6**). A model for GLS on admission was done and showed that a GLS cut-off value of ≥−14.5% had the highest sensitivity (76%) and specificity (65%) for poor outcomes, (AUC: 0.75, p = 0.002) (**Table 7** and **Fig. 3**).

Discussion

All patients in this study had subclinical LV dysfunction upon admission, as shown by impaired GLS (mean −14.4 ± 1.29), despite normal LVEF by 2D TTE. GLS had a significant correlation with admission CRP and procalcitonin levels. Furthermore, the change in GLS during the first 10

Table 2 – Baseline speckle tracking echocardiography data

	All patients (n = 46)	Favorable outcome (n = 24)	Poor outcome (n = 22)	*p*
GLS, %	−14.4 ± 1.29	−14.94 ± 1.21	−13.89 ± 1.16	**0.003**
GCS, %	−16.6 ± 2.22	−16.69 ± 1.76	−16.58 ± 2.67	0.25
LVEF, %	52.2 ± 2.86	52.92 ± 2.04	49.32 ± 2.42	**<0.001**

Values are presented as mean ± SD.
GCS – global circumferential strain; GLS – global longitudinal strain; LVEF – left ventricular ejection fraction.

Table 3 – Change in different laboratory and echocardiographic data throughout follow-up in the two study groups

	Favorable outcome (n = 24)		Poor outcome (n = 22)		*p*-value
	Admission	Discharge	Admission	Discharge*	
Laboratory markers					
∆ TLC	15.3 ± 3.98	7.88 ± 1.88	16.96 ± 4.88	10.3 ± 4.34	0.45
∆ CRP	141.79 ± 65.6	30.75 ± 22.92	200.6 ± 84.86	109.55 ± 70.46	0.23
∆ Procalcitonin	1.75 ± 0.66	0.11 ± 0.07	2.7 ± 0.93	2.26 ± 2.26	**<0.001**
Echocardiography					
Vegetation size	22.79 ± 6.07	12.88 ± 5.862	27.77 ± 5.84	22.77 ± 7.18	**<0.001**
∆ GLS	−14.94 ± 1.21	−18.5 ± 1.29	−13.89 ± 1.16	−15.8 ± 1.51	**<0.001**
∆ GCS	−16.69 ± 1.76	−19.58 ± 2.1	−16.58 ± 2.67	−18 ± 3.1	0.24
∆ LVEF	52.92 ± 2.04	56.25 ± 1.82	49.32 ± 2.42	52.76 ± 3.1	0.79

* Discharge in patients with poor hospital course is the last follow-up done before discharge, surgery, or mortality.
CRP – C-reactive protein; GCS – global circumferential strain; GLS – global longitudinal strain; LVEF – left ventricular ejection fraction; TLC – total leucocytic count.

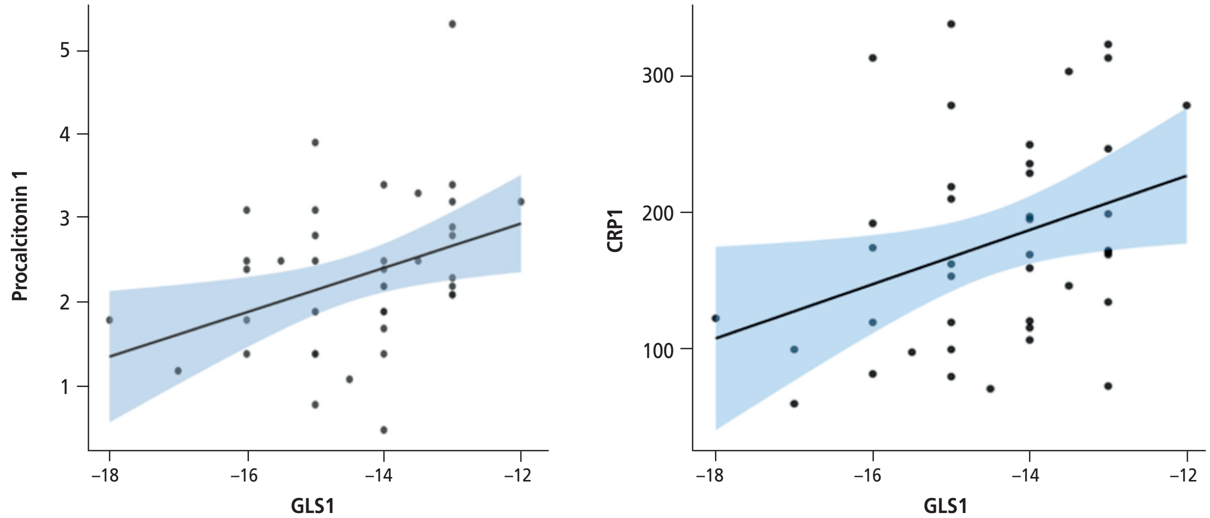

Fig. 2 – Correlation of global longitudinal strain with procalcitonin (on the left) and C-reactive protein (on the right) on admission.

Table 4 – Impact of the early rate of change of pertinent variables (from admission till the first follow-up) on outcome

	Favorable outcome (n = 24)		Poor outcome (n = 22)		*p*-value
	Admission	FU 7–10 days	Admission	FU 7–10 days	
Laboratory markers					
Δ TLC	15.3 ± 3.98	12.3 ± 3.28	16.96 ± 4.88	13.1 ± 5.01	0.35
Δ CRP	141.79 ± 65.6	109.9 ± 63.2	200.6 ± 84.86	161.3 ± 74.66	0.73
Δ Procalcitonin	1.75 ± 0.66	1.02 ± 0.45	2.7 ± 0.93	2.53 ± 1.11	**<0.001**
Echocardiography					
Vegetation size	22.79 ± 6.07	20.2 ± 5.84	27.77 ± 5.84	25.5 ± 5.84	0.61
Δ GLS	−14.94 ± 1.21	−15.9 ± 1.22	−13.89 ± 1.16	−14.7 ± 0.83	0.86
Δ GCS	−16.69 ± 1.76	−17.43 ± 1.3	−16.58 ± 2.67	−17.07 ± 3.41	0.44
Δ LVEF	52.92 ± 2.04	53.9 ± 2.1	49.32 ± 2.42	50.7 ± 2.4	0.47

CRP – C-reactive protein; GCS – global circumferential strain; GLS – global longitudinal strain; LVEF – left ventricular ejection fraction; TLC – total leucocytic count.

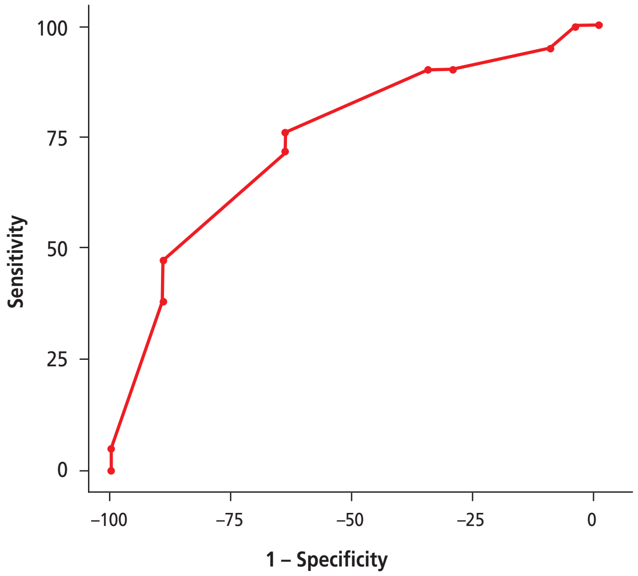

Fig. 3 – ROC curve for GLS on admission to predict poor outcomes.

Table 5 – Correlation between global longitudinal strain and different markers of infection on admission

GLS	Correlation coefficient (r)*	*p*-value
CRP	0.34	**0.031**
Procalcitonin	0.399	**0.01**
Largest vegetation size	0.36	**0.02**
Temperature	0.34	**0.02**
Vegetation number	0.033	0.84

GLS – global longitudinal strain. * Spearman's correlation coefficient.

days of hospitalization was significantly correlated with changes in the CRP levels. These findings support the hypothesis that infection has a deleterious impact on left ventricular function in IE patients.

We assessed LV function using STE, a recently proved more effective approach than standard TTE in detecting subtle changes in the myocardium in several illnesses.[6]

Myocardial dysfunction parameters have been used as predictors of outcomes in IE regardless of the etiology of the hemodynamic impairment.[7] This was based on the data from some studies that have confirmed that low LVEF is a prognostic marker of poor outcome in both left-sided and right-sided IE.[8] Many recent studies have gained GLS a lot of popularity as an early marker of LV systolic dysfunction, owing to the longitudinal arrangement of the more vulnerable subendocardial fibers of the LV in this plane of motion.[9] In our study, all patients had an impaired GLS on admission (mean −14.4 ± 1.29) as compared to the normal GLS cut-off value GLS (−20%) in the latest guidelines,[5] despite having a normal LVEF by the conventional 2D echocardiography (mean LVEF = 60.5 ± 3.57). This subclinical myocardial depression could be attributed to the virulent nature of the disease, particularly in patients with *Staphylococcus aureus* infection, the patients' late presentation, and the potential negative impact of parenteral medications on LV systolic function.

We also found a significant correlation between GLS and both CRP and procalcitonin on admission ($p = 0.03$, $p = 0.01$ respectively). Furthermore, changes in GLS during the first 10 days of admission correlated significantly with changes in the CRP levels (r = 0.33, $p = 0.037$). These findings corroborate our hypothesis that infection has a deleterious influence on LV function in IE patients. Several studies were conducted to investigate the changes that occur in GLS in patients with sepsis and septic shock, and their impact on the patients' outcomes. GLS in patients with severe sepsis and preserved LVEF was significantly lower than in critically ill, non-septic trauma patients.[10] Ng et al. reported similar longitudinal strain results in patients with septic shock.[11] In the pediatric population, Basu et al. reported that GLS was lower in septic patients than in the control group, while there was no significant difference in LVEF between the two groups.[12] In our study, patients with poor outcomes had consistently worse myocardial dysfunction measured by GLS than those with favorable outcomes. This finding remained statistically significant on admission ($p = 0.003$) and at the pre-specified intervals of follow-up ($p < 0.001$), despite a persistently preserved LVEF by TTE in both groups. This can be explained by the aggressive nature of MRSA infection which was present in 63.6% of patients with poor outcomes. Furthermore, HCV infection, which was previously linked to cardiovascular diseases via direct and indirect inflammatory pathways[13–15] was significantly higher in this group of patients than in those with favorable outcomes (54.4% versus 20.8%, $p = 0.018$).

In 2018, Lauridsen et al.[16] published the first study to establish the prognostic value of GLS in the IE population and revealed that GLS outperformed LVEF in long-term outcome risk prediction in patients with left-sided IE: GLS ≥ −15.4% had a 3-fold increased risk of 1-year mortality. Adding GLS to the recognized risk factors of long-term mortality substantially improved risk discrimination, whereas LVEF provided less additional information. In our study, a GLS cut-off value of ≥−14.5% on admission could predict poor outcomes with 76% sensitivity and 65% specificity. This is also consistent with previous studies on patients with sepsis which suggested defining LV longitudinal systolic dysfunction at GLS ≥−15%, as this cut-off value was associated with poor outcomes.[17–19]

In 2020, Capotosto et al.[20] studied the changes in LV strain in 17 patients with aortic valve IE versus 15 healthy controls and found that the GLS, LV torsion, and vegetation size (by 3D TEE) all predicted worse outcomes – the three combined gave the highest diagnostic accuracy, surpassing vegetation size or LV strain alone. Similarly, in our study, the most significant independent factors that could predict poor outcomes were the GLS ($p = 0.016$, OR 28.97, 95% CI 1.88–46.7) and the vegetation number ($p = 0.029$, OR 4.41, 95% CI 1.16–16.76).

Our study differs from the two above-mentioned studies[16,20] in two important aspects. First, we predominantly enrolled patients with right-sided IE; and being in a tertiary center, particularly during the COVID-19

Table 6 – Multivariate regression analysis of predictors of poor outcomes

Variable	Odds ratio	95% confidence interval	*p*-value
Vegetation number	28.97	1.88–446.7	**0.016**
GLS	4.41	1.16–16.76	**0.029**

GLS – global longitudinal strain.

Table 7 – Sensitivity and specificity of different GLS values to predict poor outcomes

Cut point	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC
−18	100%	0%	51.22%	–	0.750
−17	100%	5%	52.5%	100%	0.750
−16	95.24%	10%	52.63%	66.67%	0.750
−15.5	90.48%	30%	57.58%	75%	0.750
−15	90.48%	35%	59.38%	77.78%	0.750
−14.5	76.19%	65%	69.57%	72.22%	0.750
−14	71.43%	65%	68.18%	68.42%	0.750
−13.5	47.62%	90%	83.33%	62.07%	0.750
−13	38.1%	90%	80%	58.06%	0.750
−12	4.76%	100%	100%	50%	0.750

era, most of the patients who presented with aortic, mitral native, or prosthetic valve IE had either a complicated course or an urgent indication for surgery, thus were excluded from our analysis. Accordingly, 90% of our studied population had a predominantly right-sided valvular affection. Intravenous drug use (IVDU) was the most common underlying cause (91.3% of all patients). This explains the predominant male gender (80.4%) and their respective younger age (mean 32 years). The fact that left-sided IE was under-represented in our study imposed some limitations, but it well served the study's goal of detecting the changes in the left ventricle produced by the infectious disease process rather than left-sided valvular affection. Second, in addition to the baseline assessment of speckle-derived parameters, our patients underwent serial follow-up measurements to explore the possible impact of the rate of change in these parameters on the outcome.

Our study demonstrated that the LV EF derived from STE was relatively lower than the values derived from the conventional echocardiography on admission (52.2 ± 2.86 versus 60.5 ± 3.57). This finding reflects the superiority of the STE technique in detecting changes in the longitudinal and radial motion of myocardial fibers compared with the conventional two-dimensional echocardiography-derived EF.

The mortality rate in our study was 11%, which is lower than that 27.1% reported in the Egyptian IE registry by Rizk et al.[21] This can be explained by the better overall prognosis of patients with isolated right-sided IE than left-sided disease, as described by Stavi et al (2.6% versus 17% respectively, $p = 0.037$.[22] Data from the Egyptian IE registry[21] also reported an overall in-hospital complication rate of 39.4% in a population of left and right-sided IE, while in our study, 48% of patients had a complicated in-hospital disease course. The late presentation with subsequent delayed appropriate management and the aggressive *Staphylococcus aureus* infection could explain this high rate of complications.

Limitations

The study was conducted during the COVID-19 pandemic with generalized restrictions in hospital admissions resulting in a small sample size. As a tertiary center, many IE patients were referred with a complicated disease course and were excluded from the study, further reducing the sample size. Left-sided IE patients were under-represented in our study. The delayed presentation of the patients hinders applying the results to early disease presenters. Our study also lacked detailed data on the nature and duration of drug abuse.

Conclusion

Subclinical myocardial depression, detected by GLS, was present in IE patients, but was lower, and showed less improvement in those with poor in-hospital outcomes. GLS and vegetation number on admission were independent echocardiographic predictors of poor outcomes. GLS >−14.5% could predict in-hospital complications with moderate sensitivity and specificity.

Conflict of interest
None declared.

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Ethical statement and consent to participate
This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Cairo University Ethics Committee in July 2019 (MD-56-19). All patients provided their written informed consent to participate in the study. Clinical trial number: not applicable.

Consent for publication
Not applicable.

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