# Left ventricular systolic function in patients with systemic lupus erythematosus and its association with cardiovascular events

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# Left Ventricular Systolic Function in Patients with Systemic Lupus Erythematosus and Its Association with Cardiovascular Events

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*Background:* Systemic lupus erythematosus (SLE) is a chronic autoimmune disorder with potential cardiovascular involvement. The aim of this study was to assess left ventricular (LV) systolic function in a large cohort of patients with SLE using standard echocardiographic measurements and global longitudinal strain (GLS) by two-dimensional speckle-tracking analysis. Furthermore, the association between echocardiographic parameters and the occurrence of cardiovascular events was assessed.

*Methods:* A total of 102 patients with SLE (88% women; mean age, 43 ± 14 years) undergoing a dedicated multidisciplinary assessment were analyzed, including echocardiography, at the time of their first visit. A control group consisted of 50 age- and sex-matched healthy subjects.

*Results:* Compared with control subjects, patients with SLE showed impaired LV systolic function on the basis of LV ejection fraction (51 ± 6% vs 62 ± 6%, $P < .001$) and by LV GLS (−15 ± 3% vs −19 ± 2%, $P < .001$). During a median follow-up period of 2 years (interquartile range, 1–6 years), 38 patients (37%) developed cardiovascular events. Kaplan-Meier survival curves showed that patients with SLE with more impaired LV GLS (on the basis of the median value of −15%) experienced higher cumulative rates of cardiovascular events compared with those with less impaired LV GLS ($\chi^2 = 8.292$, log-rank $P = .004$). On multivariate Cox regression analysis, LV GLS demonstrated an independent association with cardiovascular events (hazard ratio, 2.171; 95% CI, 1.015–4.642; $P = .046$), whereas LV ejection fraction was not significantly associated with the outcome.

*Conclusions:* In patients with SLE, LV systolic function as measured by LV GLS is significantly impaired and associated with cardiovascular events, potentially representing a new tool to improve risk stratification in these patients. (J Am Soc Echocardiogr 2020;33:1116-22.)

*Keywords:* Left ventricular function, global longitudinal strain, systemic lupus erythematosus, cardiovascular outcome

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Systemic lupus erythematosus (SLE) is a chronic autoimmune disorder that may involve the cardiovascular system and is associated with high cardiovascular morbidity and mortality.[1,2] Diagnosis of myocardial involvement, particularly at an early stage, represents still a challenge because symptoms in patients with SLE are often nonspecific, and myocardial involvement may be present even without symptoms. Current diagnostic tools, namely echocardiography, may be limited by low sensitivity to detect myocardial dysfunction, leading to underestimation of cardiac involvement in these patients. The use of advanced echocardiographic techniques, in particular speckle-tracking echocardiography (STE), is currently proposed as a more sensitive and reproducible approach to detect subtle myocardial systolic dysfunction compared with conventional echocardiographic measures such as left ventricular ejection fraction (LVEF).[3,4] Using this imaging technique, left ventricular (LV) global longitudinal strain (GLS) can be measured, and this parameter has been shown to be clinically useful for early detection of myocardial dysfunction and risk stratification in several cardiovascular diseases, including cardiac involvement in autoimmune disorders such as systemic sclerosis.[5]

However, only small studies have assessed the diagnostic value of LV GLS for myocardial involvement in patients with SLE,[6,7] and so far no

**Abbreviations**

**CAD** = Coronary artery disease

**CVA** = Cerebrovascular accident

**GLS** = Global longitudinal strain

**HR** = Hazard ratio

**LV** = Left ventricular

**LVEF** = Left ventricular ejection fraction

**SLE** = Systemic lupus erythematosus

**SLEDAI** = Systemic lupus erythematosus disease activity index

**STE** = Speckle-tracking echocardiography

data have been published on the potential prognostic value of this measure. The purpose of the present study was therefore to assess LV systolic function in a large cohort of patients with SLE using standard and advanced echocardiographic measurements, including LV GLS; in particular, the association between LV GLS and development of cardiovascular events was explored.

## METHODS

### Patient Population

Patients referred to the Department of Rheumatology at Leiden University Medical Center for an extensive multidisciplinary assessment between May 2007 and December 2017, and who underwent echocardiographic analysis, were included in the present study.[8] Patients fulfilled the 1997 American College of Rheumatology and 2012 Systemic Lupus Erythematosus International Collaborating Clinics classification criteria for SLE.[9,10] The indication to perform echocardiography was one or more of the following: (1) potential cardiovascular symptoms (chest discomfort, dyspnea, and palpitations); (2) suspected endocarditis (cardiac murmur and other signs of endocarditis); and (3) assessment of cardiac source of embolism in case of recent cerebrovascular accident (CVA; Table 1). Diagnosis of endocarditis, pericarditis, and valvular disease was confirmed by baseline echocardiography (Table 2).

For each patient, the earliest accessible echocardiographic examination performed during the multidisciplinary assessment was analyzed. When included in the multidisciplinary assessment, all patients gave informed consent for the use of clinically collected data.

A control group was identified from the echocardiography database having structural normal hearts and consisted of 50 age- and sex-matched healthy subjects.

### Clinical Data

At inclusion, data on age, sex, duration of SLE, SLE characteristics, cardiovascular disease–related risk factors (smoking, hypertension, diabetes, dyslipidemia), comorbidities, and body mass index were recorded. Specific disease-related characteristics at baseline were also reported, including diagnosis of neuropsychiatric SLE, SLE disease activity index (SLEDAI) and Systemic Lupus Erythematosus International Collaborating Clinics 2012 classification criteria for SLE, positive antinuclear antibody, antiphospholipid antibodies, anti–double-stranded deoxyribonucleic acid, anti-Smith antibodies, elevated C-reactive protein, and reduced creatinine clearance.

Patients were followed from the baseline echocardiographic examination on for the development of cardiovascular events, which were defined as CVA, pulmonary embolism, coronary artery disease (CAD) requiring revascularization, hospitalization for heart failure, and development of sustained ventricular and/or supraventricular arrhythmias. The time till cardiovascular events was calculated from the date of echocardiography (close to the confirmed diagnosis of SLE).

**Table 1** Baseline clinical characteristics of patients with SLE ($N$ = 102)

| Clinical characteristics | Value |
|---|---|
| Age, y | 43 ± 14 |
| Sex, female | 90 (88) |
| Duration of SLE, y | 13 ± 9 |
| Systolic blood pressure, mm Hg | 123 ± 17 |
| Diastolic blood pressure, mm Hg | 74 ± 10 |
| Cardiovascular disease–related factors | |
| Hypertension | 32 (31) |
| BMI, kg/m$^2$ | 24 ± 5 |
| BMI > 25 kg/m$^2$ | 35 (34) |
| Smoking | 25 (24) |
| Coronary artery disease | 1 (1) |
| History of pulmonary embolism | 2 (2) |
| History of CVA | 4 (4) |
| Previous heart failure | 0 (0) |
| Diabetes mellitus | 4 (4) |
| Hypercholesterolemia | 33 (32) |
| SLE-related factors | |
| Creatinine clearance, mL/min | 68 ± 37 |
| NPSLE | 43 (42) |
| SLEDAI score | 9 ± 8 |
| SLICC score | 0.9 ± 1 |
| Positive antiphospholipid antibodies | 35 (34) |
| Positive antinuclear antibody | 102 (100) |
| Positive anti–double-stranded DNA | 59 (58) |
| Positive anti-Smith antibodies | 14 (14) |
| C-reactive protein, mg/L | 12 ± 30 |
| Medications | |
| Prednisolone | 51 (50) |
| Azathioprine | 24 (24) |
| Hydroxychloroquine | 45 (44) |
| Cardiovascular medications | |
| ACE inhibitors/ARBs | 18 (18) |
| $\beta$-blockers | 9 (9) |
| Diuretics | 9 (9) |
| Calcium channel blockers | 9 (9) |
| Vitamin K antagonists or NOACs | 12 (12) |

*ACE*, Angiotensin-converting enzyme; *ARB*, angiotensin receptor blocker; *BMI*, body mass index; *DNA*, deoxyribonucleic acid; *NOAC*, novel oral anticoagulant; *NPSLE*, neuropsychiatric SLE; *SLICC*, Systemic Lupus Erythematosus International Collaborating Clinics.

### Echocardiography

Commercially available ultrasound systems equipped with M5S transducers (Vivid 7 or E9, GE Vingmed Ultrasound, Horten, Norway) were used to acquire two-dimensional, color, continuous, and pulsed-wave Doppler data from the parasternal and apical views with the patient in the left lateral decubitus position. Images were stored digitally on hard disks for offline analysis (EchoPAC version 202; GE Medical Systems, Milwaukee, WI). LV end-diastolic and

## HIGHLIGHTS

- In SLE patients, LV systolic function as measured by LV GLS is significantly impaired.
- Impaired LV GLS in SLE patients is associated with cardiovascular events.
- Assessment of LV GLS may significantly improve risk-stratification in SLE patients.

end-systolic volumes were measured from the apical two- and four-chamber views using the Simpson method, and LVEF was derived.[11] LV mass was calculated and defined according to current recommendations and guidelines.[11] Left atrial volume was calculated using the Simpson method and indexed to body surface area.[11]

Transmitral inflow pattern was measured using pulsed-wave Doppler (E wave), and Doppler tissue imaging was applied at the septal and lateral mitral annulus during early diastole (average e′ and E/e′ ratio). LV diastolic function was considered normal if more than half of the following variables did not meet the cutoff values for identifying abnormal function: annular septal e′ velocity $< 7$ cm/sec, annular lateral e′ velocity $< 10$ cm/sec, average E/e′ ratio $> 14$, left atrial maximum volume index $> 34$ mL/m$^2$, and peak tricuspid regurgitation velocity $> 2.8$ m/sec. LV diastolic dysfunction was defined when more than half of the available parameters met the aforementioned cutoff values. LV diastolic function was indeterminate if half of the parameters did not meet these cutoff values.[12]

Systolic pulmonary artery pressure was estimated by determining right ventricular systolic pressure, calculated from the tricuspid regurgitation peak gradient, and adding right atrial pressure estimated by the inferior vena cava diameter and degree of respiratory collapse according to current recommendations.[13]

**Table 2** Baseline echocardiographic characteristics in patients with SLE compared with healthy control subjects

| Echocardiographic characteristic | SLE group ($n$ = 102) | Healthy control subjects ($n$ = 50) | $P$ |
|---|---|---|---|
| LV mass, g | 141 ± 57 | 130 ± 35 | .159 |
| LVEDV, mL | 93 ± 33 | 108 ± 31 | **.005** |
| LVEF, % | 51 ± 6 | 62 ± 6 | **<.001** |
| LVEF ≤ 50% | 46 (45) | 0 | **<.001** |
| LV GLS, % | −15 ± 3 | −19 ± 2 | **<.001** |
| e′ lateral, cm/sec | 12 ± 3 | 12 ± 3 | .587 |
| e′ septal, cm/sec | 9 ± 2 | 10 ± 2 | **.014** |
| e′ average, cm/sec | 10 ± 3 | 11 ± 3 | .272 |
| E/e′ ratio | 8 (6–10) | 7 (6–8) | **.001** |
| E/A ratio | 1.1 (0.9–1.4) | 1.1 (0.9–1.3) | .752 |
| E, cm/sec | 82 (68–99) | 70 (60–82) | **.010** |
| LAVI, mL/m$^2$ | 26 ± 9 | 23 ± 6 | .112 |
| sPAP, mm Hg | 20 (15–26) | 17 (9–22) | **<.001** |
| LV diastolic dysfunction | 4 (4) | 0 | .154 |
| LV diastolic function indeterminate | 9 (9) | 0 | **.029** |
| Moderate to severe VHD | 33 (32) | 0 | **<.001** |
| Libman-Sacks endocarditis | 2 (2) | 0 | .319 |
| Pericarditis | 7 (7) | 0 | .055 |
| PFO | 5 (5) | 0 | .111 |

*LAVI*, Left atrial volume index; *LVEDV*, LV end-diastolic volume; *PFO*, patent foramen ovale; *sPAP*, systolic pulmonary artery pressure; *VHD*, valvular heart disease.
Bold values represent $P < 0.05$.
Data are expressed as mean ± SD, as number (percentage), or as median (interquartile range).

### Two-Dimensional Speckle-Tracking Strain Echocardiography

LV GLS was measured on two-dimensional STE using commercially available software (EchoPAC version 202).[14] In the apical three-, four-, and two-chamber views, the LV endocardial border was traced, and the software displayed a region of interest automatically encompassing the LV myocardial wall; if needed, the region of interest was adjusted manually. LV GLS was then calculated as the average of longitudinal strain values of each apical view, and a color-coded 17-segment bull's-eye plot was provided (Figure 1).

### Statistical Analysis

Continuous variables are presented as mean ± SD if normally distributed or as median and interquartile range otherwise. Categorical variables are presented as frequencies and percentages. Patients with SLE were compared with 50 healthy control subjects, matched for age and sex, using the independent-samples $t$ test. One-way analysis of variance and the Mann-Whitney test were used for normally distributed and skewed variables, respectively, whereas the $\chi^2$ test was used to compare categorical variables. Cumulative event rates were analyzed on the basis of the Kaplan-Meier survival method for patients divided into two groups on the basis of median LV GLS value (−15%) and compared using the log-rank test. The association between LV GLS and cardiovascular events was evaluated using uni- and multivariate Cox regression analyses. The level of significance for variables to be included in the multivariable analysis was set at $P < .05$, but other clinically crucial variables (such as sex) were also included in the multivariate model. Hazard ratios (HRs) and 95% CIs are presented.

Statistical analysis was performed using SPSS for Windows version 23.0 (IBM, Armonk, NY). A two-tailed $P$ value $< .05$ was considered to indicate statistical significance.

## RESULTS

### Baseline Clinical Characteristics

A total of 102 patients with SLE (88% women; mean age, 43 ± 14 years) were included in this analysis. Clinical characteristics of the overall population are presented in Table 1. All patients had neuropsychiatric symptoms, but after the extensive multidisciplinary assessment, only 43 patients (42%) were diagnosed with neuropsychiatric SLE. Mean SLEDAI was relatively high in the overall cohort. The prevalence of comorbidities was as follows: 32 of patients with SLE (31%) had hypertension (any grade), one (1%) had previously diagnosed CAD, four (4%) had diabetes mellitus, and 33 (32%) had hypercholesterolemia. The presence of antiphospholipid antibodies was observed in 35 patients (34%).

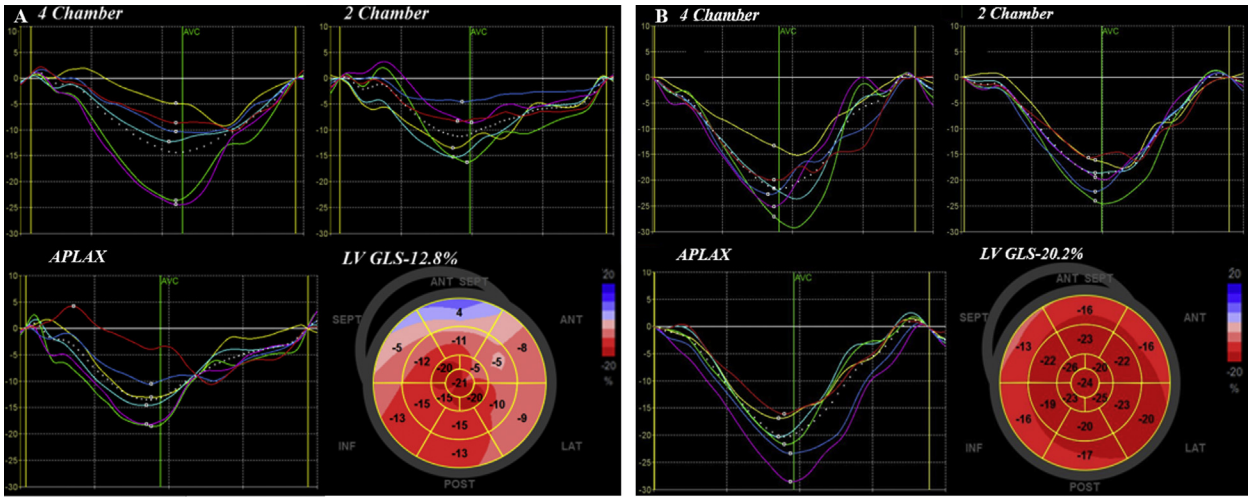



**Figure 1** Example of assessment of LV GLS by speckle-tracking strain echocardiography in patients with SLE (**A**; LV GLS = −12.8%) compared with a healthy individual (**B**; LV GLS = −20.2%) displayed with color-coded bull's-eye plots for longitudinal strain. Curves of longitudinal strain per segment and averaged among the segments (*dotted line* for the three-chamber, four-chamber, and two-chamber apical views) are also displayed. *APLAX*, Apical long-axis.

### Baseline Echocardiographic Characteristics

Baseline echocardiographic characteristics of the overall population are presented in Table 2. When comparing echocardiographic measures between patients with SLE and age- and sex-matched healthy control subjects, patients with SLE showed significantly lower LVEFs (51 ± 6% vs 62 ± 6%, $P < .001$) compared with healthy control subjects (Table 2). Although no patients with SLE were known to have heart failure symptoms, 46 of patients with SLE (45%) had slightly impaired LVEFs (≤50%). Importantly, LV GLS was also significantly decreased in patients with SLE compared with healthy control subjects (median, −15 ± 3% vs −19 ± 2%; $P < .001$). As both measures of LV systolic function, LVEF and LV GLS showed a significant correlation ($r = 0.679$, $P < .001$); however, a larger percentage of patients (89% [91 patients]) showed impaired LV GLS on the basis of the lower cutoff of normality proposed by current recommendations (−18%),[15] and therefore 50% of patients with preserved LVEFs showed impaired LV GLS.

When assessing LV diastolic function, we observed that the prevalence of LV diastolic dysfunction was not very high (Table 2), at 4% in the overall population and 9% indeterminate.

### Associations between Echocardiographic Characteristics and Cardiovascular Events

During a median follow-up period of 2 years (interquartile range, 1–6 years), 38 patients (37%) developed cardiovascular events: 14 (14%) developed CVAs, 14 (14%) arrhythmias, five (5%) CAD requiring revascularization, and four (4%) pulmonary embolism, and four (4%) were hospitalized for heart failure (Figure 2).

Kaplan-Meier survival curves show that patients with SLE with more impaired LV GLS (on the basis of the median value of −15%) experienced higher cumulative rates of cardiovascular events compared with patients with less impaired LV GLS (≤−15%; $\chi^2 = 8.292$, log-rank $P = .004$; Figure 3). At 4-year follow-up, 18% of patients with SLE with less impaired LV GLS (≤−15%) developed cardiovascular events compared with 47% with more impaired LV GLS (>−15%).

In multivariate Cox regression models (Table 3), LV GLS demonstrated a significant and independent association with cardiovascular events (HR, 2.171; 95% CI, 1.05–4.642; $P = .046$), together with age (HR, 1.044; 95% CI, 1.018–1.070; $P = .001$); conversely, LVEF was not significantly associated with cardiovascular events (HR, 0.963;

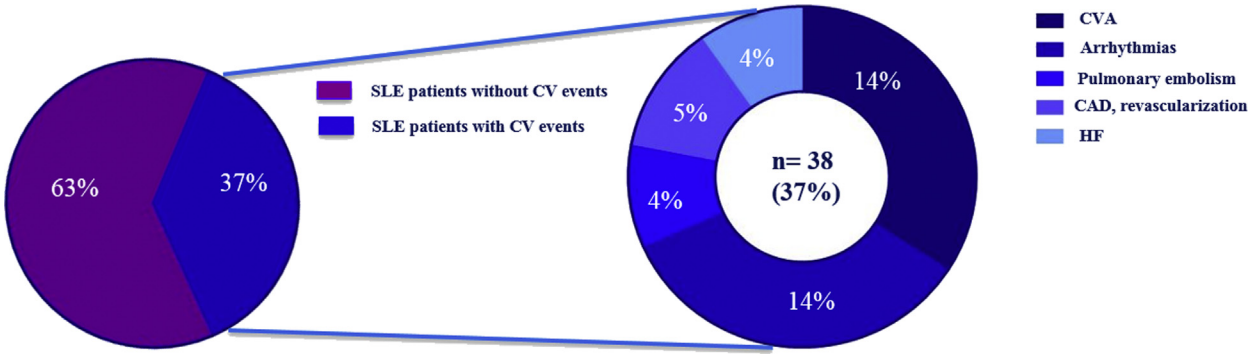
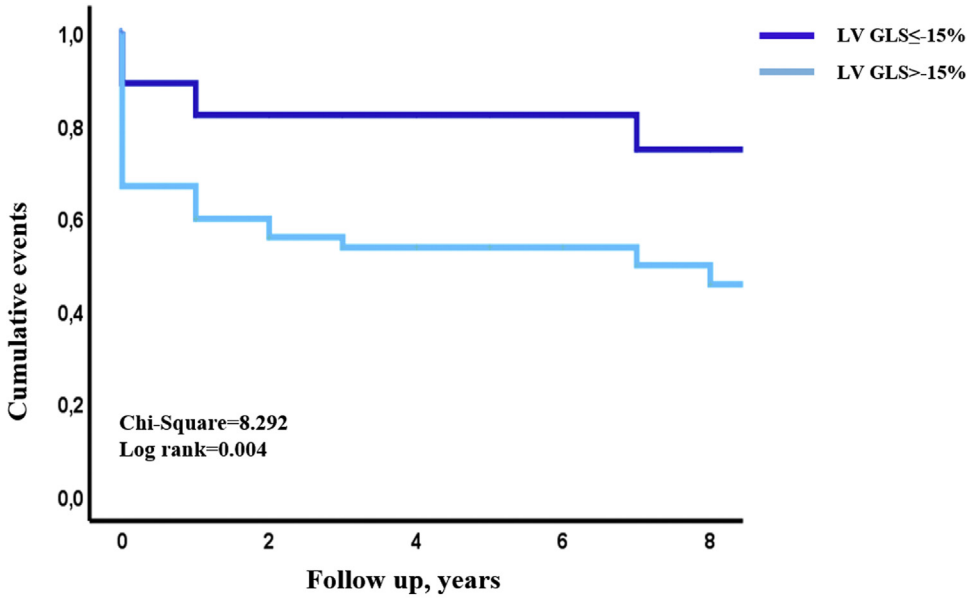



**Figure 2** Prevalence of cardiovascular events during follow-up in patients with SLE. *HF*, Heart failure.




| | | | | |
|---|---|---|---|---|
| LV GLS ≤-15% (n=44) | 28 (82%) | 18 (82%) | 11 (75%) | 5 (74%) |
| LV GLS >-15% (n=58) | 29 (60%) | 22 (53%) | 14 (50%) | 11 (46%) |

Figure 3 Kaplan-Meier curves showing the association of LV GLS (dichotomized according to median value of −15%) with the development of cardiovascular events.

95% CI, 0.915−1.014; $P = .156$) in the SLE population (Table 3), nor the parameters of LV diastolic function (Table 3).

Importantly, there was no significant association between the severity of disease (based, for example, on the SLEDAI or on the diagnosis of neuropsychiatric SLE) and cardiovascular events.

## DISCUSSION

The main findings of the present study can be summarized as follows: (1) in patients with SLE, LV systolic dysfunction was relatively frequent, and LV GLS in particular was significantly impaired compared with healthy control subjects, and (2) in these patients, impaired LV GLS was independently associated with the occurrence of cardiovascular events, whereas standard echocardiographic parameters were not.

### LV Systolic Dysfunction in Patients with SLE

In patients with SLE, the long-term inflammatory burden and the immune system abnormalities can result in several forms of cardiovascular involvement, including valvular heart disease, myocarditis, myocardial fibrosis, pericarditis, inflammatory, and atherosclerotic and thromboembolic changes in the vascular system, leading to early CAD, congestive heart failure, electrical disturbances leading to arrhythmias and conduction abnormalities, pulmonary embolism, and CVAs.[1,16-18] However, myocardial involvement at early stage of SLE is still largely underdiagnosed, because of the subtle clinical manifestations and the limitations of current diagnostic tools. Studies based on autopsy have shown myocardial involvement in 40% to 50% of patients with SLE,[16,19] while only 7% to 10% of patients with SLE are clinically diagnosed with myocardial injury.[20] In the present study, a large cohort of patients with SLE was studied using standard and advanced echocardiographic measures. Of note, 43 patients (42%) were diagnosed with neuropsychiatric SLE. In this regard, the true prevalence of neuropsychiatric SLE is unknown, but earlier studies suggest that it may affect 12% to 80% of patients with SLE[21-24] and that it is a major source of morbidity and mortality.[21,24] In this population, when using conventional parameters of LV systolic function such as LVEF, a relatively high percentage of patients (45%) showed mild LV systolic dysfunction, although with a low prevalence of comorbidities such as diabetes and CAD and without heart failure symptoms. Furthermore, when assessing LV function with a more sensitive tool such as LV GLS, the mean value was significantly lower (−15 ± 3%) than in healthy subjects (control group) and in a large percentage of patients was substantially impaired according to the normal values (−18% to −21%) proposed by current recommendations.[15] These findings therefore suggest primary myocardial involvement due to SLE, but still at a subclinical level. Previous studies have also explored the prevalence of LV systolic dysfunction in patients with SLE, and when using the reduction of systolic function in standard echocardiographic parameters such as LVEF, it varied from 16% to 45%.[24-26] Initial studies have also shown an impairment of LV GLS in patients with SLE. Buss *et al.*[6] showed, in 67 young patients with SLE, significant impairment in LV GLS compared with healthy control subjects, and similar results were obtained by Huang *et al.*[7] in 34 consecutive patients with SLE.

Table 3 Cox regression uni- and multivariate analyses for the occurrence of cardiovascular events in the patients with SLE

| Clinical or echocardiographic parameter | Univariate analysis | | Multivariate analysis | |
|---|---|---|---|---|
| | HR (95% CI) | *P* | HR (95% CI) | *P* |
| Age | 1.047 (1.022–1.072) | **<.001** | 1.044 (1.018–1.070) | **.001** |
| Sex, female | 2.493 (0.599–10.372) | .209 | 2.529 (0.608–10.518) | .202 |
| SBP | 1.014 (0.994–1.034) | .164 | | |
| Hypertension | 1.350 (0.671–2.717) | .400 | | |
| Diabetes mellitus | 2.580 (0.788–8.448) | .117 | | |
| Hypercholesterolemia | 0.529 (0.231–1.209) | .131 | | |
| Creatinine clearance | 1.002 (0.993–1.012) | .599 | | |
| NPSLE | 1.254 (0.662–2.375) | .488 | | |
| SLEDAI | 0.998 (0.959–1.038) | .912 | | |
| Antiphospholipid antibodies | 0.964 (0.483–1.923) | .918 | | |
| LVEF | 0.963 (0.915–1.014) | .156 | | |
| LVEDV | 1.001 (0.992–1.011) | .818 | | |
| Average E/e′ ratio | 1.098 (0.997–1.208) | .057 | | |
| e′ septal < 7 cm/sec | 1.884 (0.889–3.991) | .098 | | |
| LAVI | 1.017 (0.986–1.049) | .282 | | |
| LV diastolic dysfunction | 2.608 (0.794–8.564) | .114 | | |
| sPAP | 1.026 (0.999–1.053) | .059 | | |
| LV GLS (median value, −15%) | 2.640 (1.246–5.591) | **.011** | 2.171 (1.015–4.642) | **.046** |

*LAVI*, Left atrial volume index; *LVEDV*, LV end-diastolic volume; *NPSLE*, neuropsychiatric SLE; *SBP*, systolic blood pressure; *sPAP*, systolic pulmonary artery pressure.

### Clinical and Echocardiographic Associates of Cardiovascular Events in SLE

Cardiovascular complications are among the most common causes of death in patients with SLE.[1,2] Although several studies have identified clinical prognostic factors in patients with SLE, few of them focused on cardiovascular events, and no studies so far have explored the prognostic value of advanced echocardiographic measures such as LV GLS. According to the literature, the occurrence of cardiovascular events varies from 25% to 55% in SLE and neuropsychiatric SLE groups.[17,18] In the present study, a high incidence of cardiovascular events (37%) was observed.

The mechanism behind the occurrence of cardiovascular events in patients with SLE is largely unknown and probably multifactorial, including disease-specific factors; however, systematic reviews and meta-analyses demonstrated that the activity and severity of the disease, expressed namely by the systemic SLE damage and SLEDAI scores, as well as disease duration, have a small prognostic impact on cardiovascular events.[17,27,28] The limited prognostic value of the SLEDAI score also observed in our study might be explained by the fact that some important alterations, such as myositis, hemolytic anemia, and cardiopulmonary and gastrointestinal manifestations, are not considered, and the score therefore does not capture the severity of the disease within an organ system. Also, although the prevalence of hypertension (any stage) and positive antiphospholipid antibodies (not antiphospholipid syndrome) was remarkable in our study population, these variables did not show significant associations with cardiovascular events (Table 3).

In the present study, when exploring the association between echocardiographic parameters and the occurrence of cardiovascular events, only LV GLS was significantly associated with the outcome, independent of age and sex; in particular, LVEF and LV diastolic function were not significantly associated with outcome. LV GLS may be therefore able to reflect not only primary (subclinical) myocardial involvement but also an overall increased risk for cardiovascular events with different mechanisms (including autoimmune inflammation, specifically at a vascular level, increased antiphospholipid antibodies, etc.). Even in the presence of nearly "normal" LVEF, micro- and macrovascular abnormalities might affect LV GLS and can lead to CVA, arrhythmias, and other cardiovascular events. Recently, the association of subclinical LV myocardial dysfunction by GLS and incident atrial fibrillation was reported in patients with ischemic stroke.[29] In a community-based cohort study in patients free of cardiovascular disease, GLS was associated with silent brain infarcts and white matter hyperintensities, both features of small-vessel disease.[30]

LV GLS could be therefore considered as a new tool to diagnose subclinical myocardial involvement and to optimize individual patient management and risk stratification.

### Study Limitations

Several limitations should be acknowledged. In the present study, 42% of the patients had diagnosis of neuropsychiatric SLE; therefore, the results cannot be applied to an SLE population with a lower prevalence of neuropsychiatric SLE. Potential bias could be also present

because patients were selected on the basis of the availability of two-dimensional transthoracic echocardiographic findings. Because of the small number of cardiovascular events, multivariate analysis was performed including a limited number of variables; however, all statistically or clinically relevant parameters could be included. Further studies with larger populations, in a multicenter setting, should confirm these results.

## CONCLUSION

In patients with SLE, LV systolic function as measured by LV GLS is significantly impaired, compared to healthy control subjects, and is associated with cardiovascular events. Implementation of LV GLS in the early assessment of these patients may significantly improve their risk stratification.

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