Evaluation of torsion and twist mechanics of the left ventricle in patients with systemic lupus erythematosus

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Abstract

Objective: Myocardial involvement in systemic lupus erythematosus (SLE) has great importance. The aim of this study is to evaluate the rotation and twisting mechanics of the left ventricle (LV) in patients with SLE.

Methods: Forty-three patients fulfilled at least four of the American College of Rheumatology criteria for SLE and 30 individuals as controls were included in the study. SLE disease activity was assessed using the SELENA–SLEDAI score. Echocardiography was performed for all subjects. The patients fulfilled at least four of the American College of Rheumatology criteria for SLE were enrolled in the study. SLE disease activity was assessed using the SELENA–SLEDAI score. Echocardiography was performed for all individuals. Comparisons between groups were made using independent samples t-test with the standard statistical software (SPSS, version 15.0; SPSS Inc., Chicago, IL, USA). Each image was digitally stored for offline analysis. Measurement of global strain assessed by 17-segment model and rotational parameters were performed. LV ejection fraction was calculated by the biplane Simpson’s method. Comparisons between groups were made using the independent samples t-test with the standard statistical software. A p value of 0.05 was considered statistically significant.

Results: The values of mean global longitudinal strain, basal global circumferential strain (GCS), mean basal radial strain, and apical GCS were significantly lower in SLE patients. The difference between basal rotation, apical rotation, twist of the LV, and torsion of the LV in the SLE patients and controls were not significant (8.8±5.5 vs. 10.6±5.8, p=0.183; -4.7±3.0 vs. -4.8±3.2, p=0.947; 11.7±6.4 vs. 13.2±6.4, p=0.366; and 1.8±0.8 vs. 1.9±2.3, p=0.725, respectively). Although there was not any significant relationship between SELENA–SLEDAI score and myocardial strain analyses of the LV, the basal rotation and the torsion of the LV were lower in patients with SLE having a SLEDAI score of ≥17 (p=0.024 for basal rotation and p=0.032 for torsion).

Conclusion: The number of segmental and global strain analyses were decreased in SLE patients with globally normal LVEF. The twist and torsion mechanics of the LV were preserved according to the control group, and the left ventricular torsion and basal rotation were found to be significantly decreased in those with an activity score of ≥17. (Anatol J Cardiol 2016; 16: 434-9)

Keywords: systemic lupus erythematosus, echocardiography, left ventricular mechanics, strain, torsion, and twist

Introduction

The prevalence of cardiac involvement in systemic lupus erythematosus (SLE) was reported to be up to >50%; therefore, cardiovascular disease has been acknowledged as a primary cause of morbidity and mortality in SLE (1). The increased risk of cardiovascular disease in SLE was first recognized in 1976 by Urowitz et al. (2) who described a bimodal pattern of mortality in their Toronto SLE cohort. The bimodal distribution of mortality risk factors in lupus is an “early” peak in mortality caused by disease activity and severity itself, whereas a “late” peak is related to cardiovascular diseases.

Although cardiac manifestations are often mild, myocarditis is the most characteristic feature of myocardial involvement. It has been reported that segmental areas of hypokinesis can be indicative for the disease; however, large echo series have found frequencies of global hypokinesis between 5% and 20% (3). The individuals are usually asymptomatic.

Assessment of the left ventricle (LV) rotation may provide important insights into different types of myocardial dysfunction. Left ventricular twist plays a pivotal role in the mechanical efficiency of the heart, making it possible that only 15% fiber shortening results in a 60% reduction in left ventricular volume (4). Left ventricular torsion, defined as the wringing motion of the heart as the apex rotates with respect to the base around the LV long-axis, plays an important role in LV ejection and filling (5).

Because subclinical features are more prevalent than clinically apparent disease, they can only be recognized by
echocardiography and other non-invasive tests (6). Therefore, we sought to evaluate the rotation and twisting of the LV if the LV ejection and filling was affected because of segmental or global hypokinesis in asymptomatic patients with SLE.

Methods

Study design

Forty three patients fulfilled at least four of the American College of Rheumatology criteria for SLE (7) and demographic and clinical properties matched 30 control subjects were enrolled in the study. None of the individuals had diabetes. SLE disease activity was assessed using the SELENA-SLEDAI score (8, 9). Echocardiography was performed for all individuals. Comparisons between groups were made using independent samples t-test with the standard statistical software (SPSS, version 15.0; SPSS Inc., Chicago, IL, USA). The study was approved by the Local Ethical Committee at our institution.

Study population

Forty-three asymptomatic patients with SLE and 30 individuals as controls according to their demographic and clinically properties such as age, gender, hypertension (HT), or smoking were enrolled in the study. Extensive screening for coronary artery disease was undertaken in all cases. Exercise stress test or myocardial perfusion scintigraphy were performed for the patients. Patients with known coronary artery disease or symptoms of angina, positive exercise stress test, left bundle branch block in ECG, arrhythmia, pericarditis, pulmonary hypertension, congestive heart failure, stroke, renal failure, and peripheral arterial disease were excluded. None of them had diabetes. We also excluded the patients with other forms of autoimmune diseases.

Echocardiography

The base and apex of the LV rotate in opposite directions. The term torsion is used for defining the base-to-apex gradient in the rotation angle along the longitudinal axis of the LV, expressed in degrees per centimeter or radians per meter. The absolute apex-to-base difference in LV rotation (also in degrees or radians) is stated as the net LV torsion angle. (10). The LV comprises obliquely oriented muscle fibers that vary from a smaller radius, right-handed helix at the subendocardium to a larger-radius, left-handed helix at the subepicardium. Systolic twisting deformation resulting from clockwise basal rotation and counterclockwise apical rotation as seen from the apex is the functional consequence of this three-dimensional helical structure.

Two-dimensional grayscale harmonic images at a frame rate of 60–80 frames/s were obtained in the left lateral decubitus position using a commercially available system (Vivid 7; GE, Horten, Norway). For each view, three consecutive cardiac cycles were acquired during a breath hold and digitally stored on a magneto-optical disc for offline analysis. Measurement of global strain assessed by a 17-segment model and rotational parameters were performed using dedicated software (Echopac PC, version 10.0; GE Medical Systems). For the assessment of myocardial strain using speckle tracking echocardiography, endocardial borders were manually traced in end-systole, with the software automatically tracking myocardial deformation. If poor tracking occurred, endocardial borders were readjusted manually until satisfactory tracking was achieved. Strain curves for each segment (summed average strain) were recorded. These measurements were made at apical and basal levels of visualized LV walls. Longitudinal systolic strain was measured in 2- and 4-chamber views.

Parasternal short-axis images were obtained both at the basal left ventricular and at the apical level as circular as possible. Rotation was achieved automatically by the software. Counter clockwise rotation was marked as a positive value and clockwise rotation as a negative value when viewed from the LV apex. LV twist was defined as the net difference (in degrees) of apical and basal rotations at isochronal time points and was automatically computed by the software from the values of the basal and apical rotation. LV torsion was then calculated as the ratio between LV twist (in degrees) and the LV diastolic longitudinal length (in cm) between the LV apex and the mitral plane. Aortic valve opening and closure timing was obtained by a pulsed wave Doppler tracing. LV ejection fraction was calculated by the biplane Simpson’s method according to the recommendations of the ASE (11). Peak systolic velocity (Sm) was obtained from the septal and lateral sides of the mitral annulus in the four-chamber view with appropriate TDI settings.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences version 15.0 software for Windows (Chicago, IL, USA). Categorical data are expressed as frequencies. Continuous variables were presented as mean±standard deviation. x² test was applied to compare the influence of the categorical variables. Continuous variables were analyzed with Kolmogorov–Smirnov for testing normal distribution. Comparisons between groups were made using the independent samples t-test. To analyze independent predictors, linear regression analyses were used. Intraobserver reproducibility was analyzed using Spearman’s correlation analysis.

Results

Of the 43 patients enrolled in this study, five were males (11%). We planned a study with 43 experimental subjects and 30 control subjects to reject the null hypothesis that the population means of the experimental and control groups were equal with a probability (power) 0.93. The Type I error probability associated with this test of this null hypothesis was 0.05.
There were no significant differences in terms of age, gender, hypertension (HT), or smoking between the groups, and none of the individuals had diabetes. Demographic properties and clinical characteristics of both the SLE patients and the controls are shown in Table 1. Absolute values of mean global longitudinal strain (GLS), basal global circumferential strain (GCS), mean basal radial strain (RS), and apical GCS were significantly lower in SLE patients than in patients with normal myocardium in the control group (-20.0±3.0 vs. -22.4±3.1, p<0.001; -15.3±5.1 vs. -19.4±5.5, p<0.001; -25.0±7.8 vs. -28.8±5.5, p<0.001, respectively). Myocardial segments were evaluated and anterior, anterosep-
Cardiac rotation around the long-axis is an important component of LV systolic function and LV twist that is related to myocardial contractility and structure and has been recognized as a sensitive indicator of cardiac performance (13). Buss et al. (14) showed that SLE is associated with a significant impairment of systolic and diastolic LV longitudinal function in patients without cardiac symptoms. Nevertheless, Leal et al. (15) revealed subclinical systolic dysfunction even in the right ventricle in patients with childhood-onset SLE. It has been shown that systolic twist is maintained even in patients with anterior wall myocardial infarction but with relatively preserved LV systolic function (16, 17). Similarly, we found that the twist and torsion mechanics of the LV were preserved, despite the number of segmental and global strain analyses being decreased in patients with SLE as compared with those with globally normal left ventricular EF.

SLE may tend to predominantly cause subendocardial dysfunction that results in an early preferential involvement of longitudinal LV mechanics, which can be identified even in a subclinical state. The timing of contraction–relaxation cross-over is the most vulnerable period of myofiber mechanics (18, 19). Preserved LV torsion and twist mechanics may indicate that the ability of the LV to modulate the timing of contraction–relaxation cross-over is preserved in patients with globally normal LVEF, despite the impaired left ventricular segmental strain analysis in SLE. Although the twist mechanics of the LV were preserved according to the control group, the left ventricular torsion and basal rotation were found to be significantly decreased in those with an activity score of ≥17. The interplay of multiple inflammatory mediators, including leukocytes, cytokines, chemokines, adhesion molecules, complement, and antibodies may also result in the formation of cardiovascular diseases in the pathogenesis of SLE itself (20). Moreover, it has...
already been suggested that SLE should be regarded as an equivalent to coronary heart disease, similar to diabetes [21].

Another important point in this study is that despite the preserved left ventricular twist mechanics according to the control group, the segmental and global strain analyses were found to be reduced, which may be an early indicator of the cardiovascular diseases before the symptoms begin in patients with SLE. This result may raise a question regarding SLE that whether the disease itself is enough to cause a cardiovascular disease such as diabetes in a patient depending on the disease activity assessed using the SELENA–SLEDAI score. We believe that these results in this study may indicate that the cardiac involvement is directly related to the risk score of the patients with SLE, and the left ventricular torsion and basal rotation decreases with an increasing activity score.

Despite the absence of symptoms, we believe that an ultimate goal of cardiovascular assessment to diagnose early cardiovascular disease is necessary, which will hopefully help us to prevent its progression. The evaluation of strain analysis and twist mechanics of the LV with two-dimensional speckle tracking echocardiography may be a useful technique and an important component of the cardiovascular assessment in patients with SLE.

Study limitations

We do not know the data regarding the patients with reduced left ventricular EF. Although male patients were included in this study, to completely understand the physiological principles of LV segmental strain and torsion mechanics and the future relationship between cardiovascular diseases and disease activity in patients with SLE, additional studies with large series and long-term follow-up are necessary.

Conclusion

The number of segmental and global strain analyses was decreased in SLE patients with globally normal LVEF. The twist and torsion mechanics of the LV were preserved, and the left ventricular torsion and basal rotation were significantly decreased in those with an activity score ≥17. The cardiovascular assessment to diagnose cardiovascular diseases early despite the absence of symptoms may help us to prevent its progression.

Conflicts of interest: None declared.

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References

1. D’Cruz D, Khamashita M, Hughes GRV. Cardiovascular manifestations of systemic lupus erythematosus. In: Wallace DJ, Hahn BH, eds. Dubois’ lupus erythematosus. Philadelphia: Lippincott Williams & Wilkins; 2001; 645.
2. Urowitz MB, Bookman AA, Koehler BE, Gordon DA, Smythe HA, Ogryzlo MA. The bimodal mortality pattern of systemic lupus erythematosus. Am J Med 1976; 60: 221-5.
3. Berg G, Bodet J, Webb K, Williams G, Palmer D, Ruoff B, et al. Systemic lupus erythematosus presenting as an isolated congestive heart failure. J Rheumatol 1985; 12: 1182-5.
4. Sallin EA. Fiber orientation and ejection fraction in the human left ventricle. Biophys J 1969; 9: 954-64
5. Buckberg GD. Basic science review: the helix and the heart. J Thorac Cardiovasc Surg 2002; 124: 863-83.
6. Doria A, Iaccarino L, Sarzi-Puttini P, Atzeni F, Turriel M, Petri M. Cardiovascular involvement in systemic lupus erythematosus. Lupus 2005; 14: 683-6.
7. Hochberg MC. Updating the American College of Rheumatology revised criteria for the classification of systemic lupus erythematosus. Arthritis Rheum 1997; 40: 1725.
8. Bombardier C, Gladman DD, Urowitz MB, Caron D, Chang CH. Derivation of the SLEDAI. A disease activity index for lupus patients. The Committee on Prognosis Studies in SLE. Arthritis Rheum 1992; 35: 630-40.
9. Buyon JP, Petri MA, Kim MY, Kalunian KC, Grossman J, Hahn BH, et al. The effect of combined estrogen and progesterone hormone replacement therapy on disease activity in systemic lupus erythematosus: a randomized trial. Ann Intern Med 2005; 142: 953-62.
10. Henson RE, Song SK, Pastorek JJ, Ackerman JJ, Lorenz CH. Left ventricular torsion is equal in mice and humans. Am J Physiol Heart Circ Physiol 2000; 278: H1117-23.
11. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al; Chamber Quantification Writing Group; American Society of Echocardiography’s Guidelines and Standards Committee; European Association of Echocardiography Recommendations for Chamber Quantification: A Report from the American Society of Echocardiography’s Guidelines and Standards Committee and the Chamber Quantification Writing Group, Developed in Conjunction with the European Association of Echocardiography, a Branch of the European Society of Cardiology. J Am Soc Echocardiogr 2005; 18: 1440-63.
12. Huang BT, Yao HM, Huang H. Left ventricular remodeling and dysfunction in systemic lupus erythematosus: a three-dimensional speckle tracking study. Echocardiography 2014; 31: 1085-94.
13. Park SM, Hong SJ, Ahn CM, Kim YH, Kim JS, Park JH, et al. Different impacts of acute myocardial infarction on left ventricular apical and basal rotation. Eur Heart J Cardiovasc Imaging 2012; 13: 483-9.
14. Buss SJ, Wolf D, Korosoglou G, Max R, Weiss CS, Fischer C, et al. Myocardial left ventricular dysfunction in patients with systemic lupus erythematosus: new insights from tissue Doppler and strain imaging. J Rheumatol 2010; 37: 79-86.
15. Leal GN, Silva KF, França CM, Lianza AC, Andrade JL, Campos LM, et al. Subclinical right ventricle systolic dysfunction in childhood-
onset systemic lupus erythematosus: insights from two-dimensional speckle-tracking echocardiography. Lupus 2015; 24: 613-20.
16. Takeuchi M, Nishikage T, Nakai H, Kokumai M, Otani S, Lang RM. The assessment of left ventricular twist in anterior wall myocardial infarction using two-dimensional speckle tracking imaging. J Am Soc Echocardiogr 2007; 20: 36-44.
17. Garot J, Pascal O, Diébold B, Derumeaux G, Gerber BL, Dubois-Randé JL, et al. Alterations of systolic left ventricular twist after acute myocardial infarction. Am J Physiol Heart Circ Physiol 2002; 282: H357-62.
18. Pouleur H. Diastolic dysfunction and myocardial energetics. Eur Heart J 1990; 11( Suppl C): 30-4.
19. Abe T, Ohga Y, Tabayashi N, Kobayashi S, Sakata S, Misawa H, et al. Left ventricular diastolic dysfunction in type 2 diabetes mellitus model rats. Am J Physiol Heart Circ Physiol 2002; 282: H138-48.
20. Salmon JE, Roman MJ. Accelerated atherosclerosis in systemic lupus erythematosus: implications for patient management. Curr Opin Rheumatol 2001; 13: 341-4.
21. Bulkley BH, Roberts WC. The heart in SLE and the changes induced in it by corticosteroid therapy. Am J Med 1975; 53: 243-64.