Predictors of Spontaneous Echo Contrast in Left Heart Chambers in Patients with Dilated Cardiomyopathy: Slowing Down Might not Always Mean Enjoying Life

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Abstract

Introduction: Spontaneous echo contrast (SEC) is usually detected in heart chambers as a result of reduced flow velocity in the cavity. The clinical importance of SEC lies in its association with embolic events. The aim of our study was to determine the frequency of SEC in left heart chambers in patients with dilated cardiomyopathy and predictors for its emergence. Materials and Methods: This was a prospective cross-sectional transesophageal echocardiography study conducted in 101 sinus rhythm patients with dilated cardiomyopathy. Results: Moderate-degree SEC was found in the left ventricle (LV) in around 9% of patients, in the left atrium (LA) in 12% and in left atrial appendage (LAA) in 40%. Multiple regression analysis showed that lower heart rate (95% confidence interval [CI]: 0.845–0.978; P = 0.011) and larger LV end-systolic diameter (LVESD) (95% CI: 1.034–1.394; P = 0.017) were independent predictors for LV SEC presence. Lower LV ejection fraction (LVEF) (95% CI: [−0.079]–[−0.037]; P = 0.0001) was the only independent predictor for SEC in the LA. Whereas, independent predictors for SEC in LAA were lower heart rate (95% CI: [−0.030]–[−0.003]; P = 0.018), greater LA indexed diameter (95% CI: 0.016–0.116; P = 0.010), and higher value of C-reactive protein (CRP) (95% CI: 0.0026–0.031; P = 0.027). Conclusions: SEC in left heart chambers is a frequent finding in patients with dilated cardiomyopathy in sinus rhythm. Lower heart rate and LVEF, larger LVESD and LA, as well as higher CRP, predict the presence of SEC in left heart chambers. Lower heart rate might be an essential predictor for SEC presence and severity in these patients.

Keywords: Dilated cardiomyopathy, heart rate, sinus rhythm, spontaneous echo contrast

Introduction

Spontaneous echo contrast (SEC) is the swirling “smoke like” echo detected in the heart chambers as a result of reduced flow velocity in the cavity. Most frequent causes of SEC are rheumatic mitral stenosis, mitral valve prosthesis, atrial fibrillation, dilated heart chambers, dyskinetic segments of left ventricle, and impaired myocardial contractility. The clinical importance of SEC lies in its association with embolic events. The prevalence of SEC in patients with cerebral embolic events or peripheral embolic events varies from 16% to 84%.[1-3] The purpose of this study was to determine the frequency of SEC in left heart chambers in patients with dilated cardiomyopathy and sinus rhythm, as well as predictors for its emergence.

Materials and Methods

This was a prospective cross-sectional transesophageal echocardiography (TEE) study that included 101 patients with dilated cardiomyopathy of mild- to moderate systolic dysfunction and sinus rhythm. Exclusion criteria were patients with atrial fibrillation/flutter, severe left ventricular dysfunction.

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dysfunction, prosthetic valves, and valvular disease, in whom SEC is expected. Demographic and history data, physical examination, laboratory tests, electrocardiogram (ECG), chest X-ray, transthoracic echocardiography (TTE), and TEE were obtained for each patient. According to symptoms, patients were classified by New York Heart Association (NYHA) class from I (no symptoms after ordinary activities) to IV (symptoms occur at rest).

The study was approved by the Ethical Board of our institution and written informed consent was taken from every patient that entered the study.

**Echocardiography**

TTE (Phillips iE 33) examinations and measurements were performed according to the recommendations of the American Society of Echocardiography.[4] Left ventricular end diastolic diameter (LVEDD), left ventricular end systolic diameter (LVESD), septal wall and posterior wall thickness were measured from parasternal M-mode view according to standard criteria. Left ventricular ejection fraction (LVEF) was determined from apical views with modified Simpson’s rule. LVEF <50% was considered as systolic dysfunction, whereas LVEF under 30% was considered as severe left ventricular dysfunction. Left atrial (LA) diameter was measured in two-dimensional projection at end-ventricular systole in parasternal long axis view. Measurement of LA volume was done with area-length (L) method using apical 4-chamber (A4C) and apical 2-chamber (A2C) views at ventricular end-systole (maximum LA size), whereas L was measured from back wall to line across hinge points of mitral valve. Calculation of LA volume was made by the following formula: $8/3 \pi [(A1)(A2)/L]$. Wall motion score index (WMSI) was evaluated by the 17 segment model and the sum of all scores, acquired from wall kinetics, was divided by the number of segments. Mitral annular plane systolic excursion (MAPSE) was measured in millimeters (mm) by M-mode echocardiography from four different points (septal, lateral, inferior and anterior mitral annuli) by apical four-chamber and apical two-chamber approaches and subsequently the average value was generated. LV sphericity index in end-diastole and end-systole was defined as the ratio of LV width (measured at mid-point of LV length) to LV length (measured from apex to the middle of mitral annular plane) in the four-chamber view.

TEE (Phillips iE 33) was performed in all patients that entered this study, with the main aim at analysing left atrial appendage (LAA). TEE images were analysed by two experienced cardiologists, separately. In case there were discrepancies in judgment, then a third independent cardiologist, blinded with the results, was asked to solve the dilemma. The LAA was visualized from the two-chamber longitudinal view of the left cavities. Maximum and minimum LAA area was measured by planimetry method, by tracing the LAA starting from the top of the limbus of the upper pulmonary vein along the entire appendage endocardial border. The maximal area of the LAA was measured during LAA diastole at the onset of ECG P wave, while the LAA minimal area was measured at systole during the ECG R wave. The LAA ejection fraction (LAAEF) was calculated from the following equation: $\text{LAAEF} (\%) = 100 \times (\text{LAAmax} - \text{LAAmin})/\text{LAAmax}$.

SEC was identified if dynamic “smoke-like” echos with swirling motion in the cavity were seen. SEC was classified according to Fatkin into five categories, from 0 to 4+. Level 0 indicating absence of echogenicity; level 1 showing mild SEC (minimal echogenicity only transiently detectable with optimal gain settings during the cardiac cycle); level 2 with mild-to-moderate SEC (transient SEC without increased gain settings and more dense pattern than 1+); level 3 with moderate SEC (dense swirling pattern throughout the cardiac cycle); and level 4 defined as severe SEC (intense echodensity and very slow swirling patterns).[5]

LAA flow velocities were obtained with pulsed-wave Doppler interrogation, by placing the sample volume at the orifice of the LAA. Four waves were identified: “e” wave, which represents the early diastolic emptying flow; “a” wave, which corresponds to the LAA intrinsic late diastolic contraction; early systolic negative wave, which is the LAA filling; the systolic reflection waves, which appear if the heart rate is slow enough and if the LAA function is normal. Peak “a” wave and peak systolic wave were measured.

Patients with LAA peak emptying velocity <40 cm/s and/or SEC and/or thrombus in LAA were considered as having LAA dysfunction.

**Statistical analysis**

The data were expressed as mean ± standard deviation (SD) and percentages. Comparison between two groups of continuous variables was performed using two-tailed unpaired t-test and for categorical variables using Pearson’s Chi-square test. Correlation of selected variables was estimated using Spearman’s correlation coefficient, as we assumed nonlinear correlation existence. Multiple regression analysis was used as a prediction model and the data were expressed with 95% confidence intervals (CIs) and probability value adjusted for all other measured risk factors. Variables with a value of $P < 0.05$ were considered significant. Statistical software SPSS 22.0 (IBM SPSS, Inc., Chicago, Illinois, USA) packet for statistical analysis was used.

**Results**

Basic clinical and echocardiography features are presented in Tables 1-3. In regard to patient symptoms, 15.8% of our patients belonged to NYHA class I, 68.3% were in NYHA class II, and 15.8% were classified in NYHA class III. None of our patients had severe symptoms that would classify them in NYHA class IV. One-third of the patients were diagnosed for the first time with dilated cardiomyopathy. Concerning cardiac therapy that they were taking prior to entering the study, 75% of patients were taking aspirin, 71% angiotensin-converting
Comparison of patients’ basic echocardiography features according to severity of SEC, those with lower grade SEC to patients with higher grade SEC, is shown in Table 6. As shown in this Table 6, patients with high grade SEC in the LV and LA (51 and 45 patients, respectively) had significantly larger LVEDD, lower LV EF, and average MAPSE, whereas WMSI was higher. On the other hand, the 42 patients with grade 3 and 4 sec in the LAA had significantly larger LA diameter and LAA area compared to patients with lower grade SEC.

**Discussion**

SEC was a frequent finding in the left heart cavities in our patients. However, most frequently we found SEC of mild or mild-to-moderate degree, whereas moderate and severe SEC were encountered to a much lesser rate. Therefore, moderate degree of SEC in LV was found in 9 (8.9%) patients, in LA in 12 (11.9%) patients, and in LAA in 40 (39.6%) patients, which is within the range observed by other authors. Severe form of SEC was seen in only 2 (2%) patients, located in LAA.

Findings by other authors in regard to SEC frequency in heart chambers are presented below. In random population undergoing TEE, the prevalence of SEC ranges from 3% to 20%. In smaller series of patients, we reported a high frequency of SEC in left heart chambers in patients with dilated cardiomyopathy at sinus rhythm. Siostrzonek et al. reported that 33% of patients with idiopathic dilated cardiomyopathy had LA SEC, whereas Shen et al. observed SEC in 42% of patients with idiopathic dilated cardiomyopathy.
Table 3: Characteristics of left atrial appendage size and function assessed by transesophageal echocardiography in all patients ($n=101$)

| Parameter                              | Means±SD or n (%) |
|----------------------------------------|-------------------|
| LAA maximum area (cm$^2$)              | 4.73±1.59         |
| LAA minimum area (cm$^2$)              | 2.55±1.41         |
| LAA EF (%)                             | 47.50±20.92       |
| a’ wave (cm/s)                         | 54.11±24.44       |
| Filling wave (cm/s)                    | 44.86±20.97       |
| LAA dysfunction (%)                    | 87 (86.1)         |

LAA=Left atrial appendage, EF=Ejection fraction

Table 4: Presence of spontaneous echo contrast assessed by transesophageal echocardiography in all patients ($n=101$)

| Parameter | n (%) |
|-----------|-------|
| SEC LV    |       |
| 0         | 7 (6.9)          |
| 1+        | 43 (42.6)        |
| 2+        | 42 (41.6)        |
| 3+        | 9 (8.9)          |
| 4+        | 0 (0)            |
| SEC LAA   |       |
| 0         | 5 (5.0)          |
| 1+        | 51 (50.5)        |
| 2+        | 33 (32.7)        |
| 3+        | 12 (11.9)        |
| 4+        | 0 (0)            |

SEC=L, left ventricle; LA=left atrium, LAA=left atrial appendage

Figure 1: (a and b) Transthoracic echocardiography and transesophageal echocardiography figures of a 75-year-old male patient at sinus rhythm with dilated cardiomyopathy and history of diabetes mellitus, coronary artery disease and peripheral artery disease. Left ventricle spontaneous echo contrast grade 2, left atrium spontaneous echo contrast grade 2, and left atrial appendage spontaneous echo contrast grade 3 were registered. Left ventricular end diastolic diameter was 67 mm, left atrium diameter 52 mm, and left ventricular ejection fraction was 30%. In (a), an apical left ventricle mural thrombus of 25 mm × 2 mm is depicted by transthoracic echocardiography. In (b) in a transesophageal echocardiography image of the same patient, a spherical mobile thrombus of 4 mm × 5 mm dimension is seen in left atrial appendage

account only more pronounced forms of SEC, as SEC grading was not stated in these papers. Thus, if we compare moderate and severe degree of SEC in left chamber heart cavities in our patients, we conclude that SEC frequency detected in our patients is within the range reported by other authors.

In our study, independent factors for SEC appearance in left heart chambers in patients with dilated cardiomyopathy and sinus rhythm were lower heart rate and larger LVESD for SEC in LV; lower LV EF for SEC in LA; and lower heart rate, larger LAAd/BSA, and higher CRP levels for SEC in LAA. Handke et al. in their study identified the following independent predictors of LA SEC and/or thrombus in stroke patients with sinus rhythm and LV systolic dysfunction: LAA flow velocity less than 55 cm/s and LV EF less or equal to 35%. This is in agreement with our results, as LV EF resulted to be an independent predictor for LA SEC in our patient population, also. Sadanandan and Sherrid also found decreased LAA emptying velocity as an independent predictor of LA SEC in patients with sinus rhythm, but in addition to this parameter, they also recognized LA size and history of cerebrovascular event as independent predictors. Earlier Black et al. identified atrial fibrillation, mitral stenosis, left atrial dimension, history of embolism, and mitral regurgitation as independent predictors for LA SEC appearance among the 400 patients that underwent TEE for different indications. Vincelj et al. found that LA SEC was significantly associated with atrial fibrillation, mitral stenosis, absence of mitral regurgitation, and left atrial dimension among the 290 evaluated patients undergoing TEE. Left atrial volume index, in conjunction with LA fractional shortening and acceleration slope of mitral A wave, showed to be independent TTE predictors for LA SEC in a study conducted in stroke patients with sinus rhythm. Ozer et al. described that decreased LAA flow velocity and increased LAA size are significantly associated with LAA SEC in patients with nonvalvular atrial fibrillation and history of stroke. CRP has proved to be related to LA SEC and thrombi by other authors,
Lower heart rate was an independent predictor of SEC presence in LV and LAA in our study population. In this context, Patel et al. demonstrated that by increasing heart rate in heart failure patients, with acute interventions, decreases the tendency towards stasis, thus SEC disappears or its intensity decreases.\[^{22}\] On the other hand, Bilge et al. demonstrated that acute phase beta blockade (metoprolol 5 mg bolus plus 50 mg orally twice daily for 1 week) in patients with atrial fibrillation and normal LV systolic function may have harmful effect on LAA function, it may also increase SEC (at 1 week) and cause new thrombi.\[^{24}\]

**Clinical implication of this study**

It is well known that beta blockers are indicated in heart failure patients, with the purpose of neurohormonal modification, LVEF improvement, arrhythmia prevention, and ventricular rate control. Therefore, beta blocker benefits are manifold, including reduction in mortality rates, hospitalizations and the risk of sudden death; improvement of LV function and exercise tolerance; and decrease of heart failure functional class. Accordingly, high proportion of heart failure patients take beta blocker therapy; similarly, 67% of our patients were taking beta blockers prior to entering our study. However, besides their many beneficial effects, beta blockers may have an unsafe role regarding SEC presence and severity in left heart chambers. In addition to beta-blockers, other medications that are indicated in heart failure patients, that can lower heart rate, such as digoxin and ivabradine, should be given with caution. Our statistical analysis demonstrated that reduced heart rate increases severity of SEC. Consequently, medications with negative chronotrope effect should be administered cautiously in order to maintain adequate heart rate. Further studies are needed to elucidate the role that lower heart rate in heart failure patients might have in thromboembolic events. Moreover, in the future clinical practice, this might set new bottom target for heart rate in patients with heart failure.

**Conclusions**

SEC in left heart chambers is a frequent finding in patients with dilated cardiomyopathy in sinus rhythm. Lower heart rate and LVEF, larger LVESD and LA, as well as higher CRP

### Table 5: Correlation of spontaneous echo contrast with different parameters

|          | SEC LV | SEC LA | SEC LAA |
|----------|--------|--------|---------|
| Age      | $r=0.2; P=0.045$ | / | / |
| Male gender | / | $r=0.211; P=0.034$ | / |
| History of CAD | $r=0.2; P=0.045$ | / | $r=0.284; P=0.004$ |
| Duration of DM | / | / | $r=0.404; P=0.030$ |
| NYHA class | $r=0.289; P=0.003$ | $r=0.276; P=0.005$ | / |
| HR       | $r=0.289; P=0.003$ | $r=0.200; P=0.045$ | $r=0.238; P=0.016$ |
| Packed cell volume | / | $r=0.332; P=0.001$ | / |
| Red blood cells | / | $r=0.268; P=0.007$ | / |
| CRP      | / | / | $r=0.200; P=0.044$ |
| LVEDD    | $r=0.324; P=0.001$ | $r=0.398; P=0.0001$ | / |
| LVESD    | $r=0.440; P=0.0001$ | $r=0.425; P=0.0001$ | / |
| LVEF     | $r=0.443; P=0.0001$ | $r=0.494; P=0.0001$ | / |
| WMSI     | $r=0.295; P=0.02$ | $r=0.468; P=0.0001$ | / |
| LV width diastole | $r=0.221; P=0.026$ | / | / |
| LV width systole | $r=0.270; P=0.006$ | $r=0.339; P=0.001$ | / |
| LV length diastole | $r=0.208; P=0.037$ | / | $r=0.238; P=0.016$ |
| LV width systole | / | / | / |
| MAPSE average | $r=0.330; P=0.001$ | $r=0.305; P=0.002$ | / |
| LA diameter | / | $r=0.258; P=0.009$ | $r=0.252; P=0.011$ |
| LAd/BSA | / | $r=0.256; P=0.01$ | $r=0.284; P=0.004$ |
| LA area | / | $r=0.255; P=0.01$ | / |
| LAV/BSA | / | $r=0.210; P=0.035$ | / |
| LAA area | / | / | $r=0.196; P=0.049$ |
| LAA dysfunction | / | / | $r=0.354; P=0.0001$ |

SEC=Spontaneous echo contrast, CAD=Coronary artery disease, DM=Diabetes mellitus, NYHA=New York Heart Association, HR=Heart rate, CRP=C-reactive protein, LVEDD=Left ventricular end diastolic diameter, LVESD=Left ventricular end systolic diameter, LVEF=Left ventricular ejection fraction, WMSI=Wall motion score index, LV=Left ventricle, MAPSE=Mitral annular plane systolic excursion, LA=Left atrium, Lad/BSA=Left atrial diameter/body surface area, LAA=Left atrial appendage

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predict presence of SEC in left heart chambers. Lower heart rate might be an important predictor for SEC presence and severity, thus inquiring increased awareness with negative chronotrope medication dosage.

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**Conflicts of interest**
There are no conflicts of interest.

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### Table 6: Differences in main echocardiographic findings in patients with lower grade spontaneous echo contrast compared to higher grade spontaneous echo contrast in left heart chambers

| Echocardiographic parameter | LV SEC | P       | LA SEC | P       | LAA SEC | P       |
|----------------------------|--------|---------|--------|---------|---------|---------|
| LVEDD (mm)                 | 64.8±5.8 | 0.02    | 64.9±5.4 | 0.0005  | 66.6±5.6 | 0.5     |
| LVEF (%)                   | 41.8±6.5 | <0.0001 | 41.5±6.2 | 0.01    | 45.1±4.8 | 0.0001  |
| MAPSE av (mm)              | 9.9±2.1  | 0.04    | 9.8±2.2  | 0.01    | 1.4±0.4  | <0.0001 |
| WMSI                       | 1.6±0.3  | 0.04    | 1.8±0.3  | <0.0001 | 1.8±0.4  | 0.8     |
| Diastolic dysfunction (n)  | 34      | 0.8     | 26      | 0.5     | 26       | 0.9     |
| LA (mm)                    | 45.1±4.4 | 0.05    | 47.5±5.5 | 0.048   | 47       | 0.5     |

SEC=Spontaneous echo contrast, LVEDD=Left ventricular end diastolic diameter, LVEF=Left ventricular ejection fraction, WMSI=Wall motion score index, LA=Left atrium, LAA=Left atrial appendage

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