The prevalence of left atrial spontaneous echo contrast (SEC) and the occurrence of systemic embolism were prospectively studied in 176 consecutive patients. All had significant mitral regurgitation (MR) and underwent transesophageal echocardiographic (TEE) studies. Left ventriculography was performed in all patients to document the severity of MR. The underlying causes of MR included rheumatic heart disease in 84 patients, ruptured chordae tendineae in 37, mitral valve prolapse in 18, infective endocarditis in 20, coronary artery disease in 8, congenital heart disease in 5, and dilated cardiomyopathy in 4. No patient was found to have left atrial thrombus. Left atrial SEC was observed in three patients (1.7 percent), all of whom had atrial fibrillation, concomitant mitral stenosis, and huge left atria. Color flow mapping revealed that left atrial SEC was prominent in regions where the turbulent flow of MR was not present. Systemic embolism occurred in ten patients (5.7 percent). The underlying disease was infective endocarditis, rheumatic heart disease, and dilated cardio-myopathy in 6, 3, and 1 patient, respectively. The sites of embolization involved the central nervous system in eight patients and the spleen in the remaining two. Three patients with rheumatic heart disease and the one with dilated cardiomyopathy were in atrial fibrillation and had dilated left atria (diameter >45 mm) when systemic embolism occurred. Only one patient with rheumatic heart disease was found to have left atrial SEC. The remaining six, with infective endocarditis, all had sinus rhythm. In conclusion, left atrial SEC or thrombus detected by TEE is uncommon in patients with significant MR. Clinical conditions may be of help to identify the subsets of patients at higher risk for systemic embolism.

(Chest 1994; 106:8-12)

Spontaneous echo contrast (SEC), described as smoke-like discrete reflectances in cardiac chambers or vascular channels, is most commonly seen in clinical conditions resulting in blood stasis.1-5 The visualization of SEC by transthoracic echocardiography (TTE) is an uncommon phenomenon.3-5 With the advent of transesophageal echocardiography (TEE), left atrial SEC has been observed more often, especially in patients with rheumatic mitral valve disease or nonrheumatic atrial fibrillation and has been regarded as an indicator of increased thromboembolic risk.6-10 Blood stasis is considered to presage SEC formation and, therefore, we hypothesize that turbulent flow originating from mitral regurgitation (MR) may protect against the generation of left atrial SEC. Consequently, this study investigated the prevalence of left atrial SEC and the occurrence of systemic embolism in patients with significant MR due to a variety of cardiac abnormalities.

**METHODS**

**Study Patients**

From May 1991 to April 1993, all patients diagnosed (using the criteria of Sellers) as having angiographically grade 3 or 4 MR alone or in combination with other cardiac abnormalities were enrolled in this study.11 A total of 176 consecutive patients were included and underwent TTE, TEE, and cardiac catheterization studies. The 81 men and 95 women had a mean age of 40±12 years (range, 18 to 76 years). Their underlying cardiac abnormalities included rheumatic heart disease in 84 patients, mitral
valve prolapse without ruptured chordae tendineae in 18, ruptured chordae tendineae in 37, infective endocarditis in 20, congenital heart disease in 5, coronary artery disease in 8, and dilated cardiomyopathy in 4 (Table 1).

Echocardiography

Echocardiographic studies were performed with phase-arrayed ultrasound systems (Toshiba SSH-65A, Toshiba Corp, Tokyo, Japan, and Aloka SSD-870, Aloka Co, Ltd, Tokyo, Japan). Monitor ECG with lead II was used during the echocardiographic studies. For the precordial studies, 2.5- and 3.5-MHz transducers were used. For the transesophageal studies, a 5.0-MHz biplane transesophageal probe (Aloka SSD-870) was used. Transesophageal echocardiography was performed before TEE in all patients with the procedure described previously, including parasternal long-axis and short-axis views, and apical four-chamber and two-chamber views.11,12 Transesophageal echocardiography was usually performed with the patient in the left lateral decubitus position. The patient fasted for at least 4 h before the transesophageal examination. Local anesthesia of the pharynx was achieved with 2 percent lidocaine (Xylocaine) spray to suppress the gag reflex. The heart and aorta were studied in standard transesophageal projections as previously described. All echocardiograms were recorded on videotape (U-matic Fuji KCA-60 or Sony VHS) for review. The time required for the transesophageal procedure was less than 15 min.

Left Atrial Spontaneous Echo Contrast and Thrombus

Left atrial SEC was diagnosed by the presence of dynamic smoke-like echoes within the atrial cavity, with a characteristic swirling motion distinct from white noises artifacts.9,10 Gain settings were adjusted as required to distinguish SEC from echoes due to excessive gain. The presence of left atrial thrombus was established by demonstrating a well-demarcated echogenic mass with echotexture different from that of the atrial wall, despite alterations in gain settings.11 The presence or absence of left atrial SEC or thrombus was determined independently by two echocardiographers without regard to the clinical data and any discrepancy was resolved by consensus.

**Systemic Embolism**

In addition to chart review, detailed historic information was elicited by physicians using a question list, specifically aimed at detecting embolic events. Clinical diagnosis of an embolic transient ischemic attack or stroke was made by neurologists. These were patients experiencing the abrupt onset of a focal neurologic deficit in the vascular territory of the anterior or middle cerebral arteries, with no evidence of mass or hemorrhage on head computed tomographic scan. Patients with deficits in the territory of the posterior circulation or lacunar strokes were excluded.

Angiography was used to confirm the diagnosis of peripheral embolization involving the spleen, kidney, mesenteric arteries, or extremities. Patients with vague symptoms suggestive of peripheral embolization without angiographic proof were excluded.

**RESULTS**

Only three patients had left atrial SEC detected by TEE, and no patient was found to have left atrial thrombus. Neither SEC nor thrombus could be detected in other cardiac chambers in the study population. All of the patients with left atrial SEC were the victims of rheumatic heart disease and had concomitant mitral stenosis. The prevalence of left atrial SEC was 3.6 percent in patients with rheumatic heart disease (3/84), and it was 1.7 percent in total study patients (3/176).

Atrial fibrillation is a common finding in patients with long-standing rheumatic or nonrheumatic MR, and it was found in 90 patients (51.1 percent). Mitral regurgitation resulting from infective endocarditis always has a clinical course of acute onset and, therefore, no patient was found to have atrial fibrillation. The percentage of atrial fibrillation in various cardiac disorders is also shown in Table 1.

Evidence of systemic embolism was present in ten

<table>
<thead>
<tr>
<th>Underlying Heart Diseases</th>
<th>No. of Patients</th>
<th>LA SEC (%)</th>
<th>Af (%)</th>
<th>Emb (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheumatic heart disease</td>
<td>84</td>
<td>5 (3.6)</td>
<td>55 (65.5)</td>
<td>3 (3.6)</td>
</tr>
<tr>
<td>Mitral valve prolapse</td>
<td>18</td>
<td>0</td>
<td>7 (38.0)</td>
<td>0</td>
</tr>
<tr>
<td>Ruptured chordae tendineae</td>
<td>37</td>
<td>0</td>
<td>24 (64.9)</td>
<td>0</td>
</tr>
<tr>
<td>Infective endocarditis</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>6 (30)</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>5</td>
<td>0</td>
<td>1 (20)</td>
<td>0</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>8</td>
<td>0</td>
<td>1 (12.5)</td>
<td>0</td>
</tr>
<tr>
<td>Dilated cardiomyopathy</td>
<td>4</td>
<td>0</td>
<td>2 (50)</td>
<td>1 (25)</td>
</tr>
<tr>
<td>Total</td>
<td>176</td>
<td>3 (1.7)</td>
<td>90 (51.1)</td>
<td>10 (5.7)</td>
</tr>
</tbody>
</table>

**Table 2—Characteristics of Patients With Left Atrial Spontaneous Echo Contrast**

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, yr</th>
<th>LAD, mm</th>
<th>MVA, cm²</th>
<th>PA, mm Hg</th>
<th>PG, mm Hg</th>
<th>MR</th>
<th>Af</th>
<th>Emb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/F/46</td>
<td>69</td>
<td>0.62</td>
<td>68</td>
<td>18</td>
<td>IV</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>2/M/36</td>
<td>60</td>
<td>1.08</td>
<td>44</td>
<td>9</td>
<td>III</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3/F/34</td>
<td>58</td>
<td>0.94</td>
<td>52</td>
<td>16</td>
<td>III</td>
<td>+</td>
<td>−</td>
</tr>
</tbody>
</table>

* LAD=left atrial diameter; MVA=mitral valve area estimated by pressure half-time method; PA=mean pulmonary artery pressure; PG=pulmonary capillary wedge and left ventricular end-diastolic pressure gradient; Af=atrial fibrillation; Emb=systemic embolism; minus sign=absence; plus sign=presence.
patients (5.7 percent). The underlying disease was infective endocarditis, rheumatic heart disease, and dilated cardiomyopathy in 6, 3, and 1 patient, respectively. The three patients with rheumatic heart disease and the one with dilated cardiomyopathy were in atrial fibrillation and had dilated left atria (diameter >45 mm) when systemic embolism occurred. Only one patient with rheumatic heart disease was found to have left atrial SEC. The remaining six patients with infective endocarditis all had sinus rhythm. The sites of embolization involved the central nervous system in eight patients and the spleen in the remaining two. There was no mortality solely attributable to systemic embolism in this series.

The three patients with left atrial SEC all had atrial fibrillation, concomitant mitral stenosis, and huge left atria (Table 2). The left ventricular ejection fraction from echocardiographic and cardiac catheterization studies was normal in all three patients. Color flow mapping of TEE revealed that left atrial SEC was prominent in regions where the turbulent flow from MR was not present (Figs 1 and 2).

DISCUSSION

Cardiac chambers and blood vessels are usually echolucent. The term “spontaneous echo contrast (SEC)” has been used to describe a wafting, swirling haze that is occasionally seen in great vessels and dilated cardiac chambers under conditions of blood stasis.\(^1\)\(^2\) In the left atrium, SEC was initially observed by TTE in patients with mitral stenosis.\(^3\)\(^-\)\(^5\) Visualization of SEC requires high-gain settings and high-frequency transducers, as is made possible by TEE.\(^6\) Therefore, TEE has become a sensitive method for detecting left atrial SEC.\(^7\)\(^-\)\(^10\) Clinically, the presence of left atrial SEC has been proposed as a potential marker for an increased thromboembolic risk.\(^7\)\(^-\)\(^10\)
Although the mechanism for the development of SEC is unclear, two blood components, red blood cells and platelets, have been implicated in the genesis of this phenomenon.\textsuperscript{13-16} Red blood cell aggregation in the low-flow state has been hypothesized to cause SEC in most studies. The mechanism of red blood cell aggregation is complex because of the characteristic shape of the membrane and the complex electrical charge structure.\textsuperscript{17,18} Erythrocytes repel each other by negative surface electrostatic forces, but they are also attracted to each other by electrodynamic phenomena or the van der Waals forces. The formation of erythrocyte aggregates requires the presence of macromolecules in the plasma such as $\alpha$- and $\beta$-globulins and fibrinogen; these proteins establish reversible bridges among red blood cells.\textsuperscript{19} The weak nature of this protein binding explains the reversibility of the aggregates and may account for the transient nature of SEC.\textsuperscript{20,21} Besides, because of the potential relation between thrombus formation and SEC, some studies suggest that platelet aggregates produce this echocardiographic image.\textsuperscript{13,14} Although the debate continues, the reversibility of SEC is definite.\textsuperscript{20,21} Therefore, it is assumed that turbulent flow produced by significant MR prevents blood stasis in the left atrium and is protective against SEC formation. Furthermore, the prevalence of systemic embolism in these patients warrants the present study.

The reported prevalence of TEE-detected left atrial SEC ranged from 25 to 68 percent in patients with mitral stenosis, and from 30 to 60 percent in those with mitral valve prostheses.\textsuperscript{6,9} Only three patients in the present series had left atrial SEC, a much lower prevalence rate than that in patients with mitral valve disease. The result is consistent with our hypothesis that significant MR disperses the aggregation of blood components.

Stroke remains a major health care problem in developing countries. Currently, there is evidence for the benefit of anticoagulation only in those patients who have a cardiac cause of stroke, while patients with atherosclerotic disease benefit from antplatelet therapy.\textsuperscript{22,23} It is thus important to correctly identify patients with potential cardiac sources of embolism. Transesophageal echocardiography has been reported to increase significantly the detection of potential cardiac sources of embolism and may be useful in the treatment of patients with recent cerebral ischemic events or systemic embolism.\textsuperscript{24-27} Anticoagulation should also be given in patients at higher risk for systemic embolism unless contraindicated. Left atrial SEC is one of the conditions associated with an increased thromboembolic risk.\textsuperscript{6,10} This is better visualized with a high-frequency transducer such as the 5-MHz transducer used with TEE. We have found that left atrial SEC is rarely present in patients with significant MR, but the risk for systemic embolism still exists, especially in patients with atrial fibrillation and dilated left atria due to rheumatic heart disease or dilated cardiomyopathy and patients with infective endocarditis even in sinus rhythm.

In conclusion, left atrial SEC or thrombus detected by TEE is uncommon in patients with significant MR. Despite this, clinical conditions may be of help in identifying the subsets of patients at higher risk for systemic embolization. These include patients with infective endocarditis or those having atrial fibrillation and dilated left atria from rheumatic heart disease or dilated cardiomyopathy. Prevention of embolic complications should be appropriately administered in these patients, even in the absence of TEE-detected left atrial SEC or thrombus.

**References**


Chest / 106 / 1 / JULY, 1994
transesophageal echocardiography. Am J Cardiol 1992; 70:1152-56
14 Mahony C, Evans JM, Spain C. Spontaneous contrast and circulating platelets [abstract]. Circulation 1990; 80(suppl II):II-1
18 Fabry TL. Mechanism of erythrocyte aggregation and sedimentation. Blood 1987; 70:1572-76
19 Yuan YW, Shung KK. Ultrasonic backscatter from flowing whole blood: II. Dependence on frequency and fibrinogen concentration. J Acoust Soc Am 1988; 84:1195-1200