Subclinical Brain Embolization in Left-Sided Infective Endocarditis
Results From the Evaluation by MRI of the Brains of Patients With Left-Sided Intracardiac Solid Masses (EMBOLISM) Pilot Study

Howard A. Cooper, MD; Elissa C. Thompson, MD; Robert Laureno, MD; Anthon Fuisz, MD; Alexander S. Mark, MD; Mark Lin, MD; Steven A. Goldstein, MD

Background—Acute brain embolization (ABE) in left-sided infective endocarditis has significant implications for clinical decision making. The true incidence of ABE, including subclinical brain embolization, is unknown.

Methods and Results—We prospectively studied 56 patients with definite left-sided infective endocarditis. Patients were examined by a study neurologist, and those without contraindication had magnetic resonance imaging of the brain. Patients without clinical evidence of acute stroke but with magnetic resonance imaging evidence of ABE were considered to have subclinical brain embolization. Clinical stroke was present in 14 of 56 patients (25%). Among 40 patients undergoing magnetic resonance imaging, the incidence rates of subclinical brain embolization and any ABE were 48% and 80%, respectively. ABE was present in 18 of 19 patients (95%) with Staphylococcus aureus infection. At 3 months, mortality was similar among patients with clinical stroke and subclinical brain embolization (62% versus 53%; P=NS) and was higher among patients with any ABE than among those without ABE (56% versus 12%; P=0.046). Valvular surgery was performed in 25 patients (45%), including 16 with ABE, at a median of 4 days. No patient suffered a postoperative neurological complication. Surgery was independently associated with a lower risk of mortality at 3 months (odds ratio, 0.1; 95% confidence interval, 0.03 to 0.6; P=0.008).

Conclusions—Magnetic resonance imaging detected subclinical brain embolization in a substantial number of patients with left-sided infective endocarditis, suggesting that the incidence of ABE may be significantly higher than reports based on clinical and computed tomography findings have indicated. Brain magnetic resonance imaging may play a role in the complex decision about surgical intervention in infective endocarditis. (Circulation. 2009;120:585-591.)

Key Words: infective endocarditis ■ magnetic resonance imaging ■ stroke ■ surgery

A acute brain embolization (ABE) resulting from left-sided infective endocarditis (IE) is associated with substantial morbidity and mortality and therefore has significant implications for clinical decision making.1,2 Clinically apparent ABE (ie, acute embolic stroke) is estimated to occur in 10% to 30% of patients with left-sided IE.3–8 In addition, systematic use of computed tomography (CT) of the brain in IE patients reveals the presence of subclinical brain embolization (SCBE) in a small percentage of patients.9–11 Furthermore, isolated case reports demonstrate that magnetic resonance imaging (MRI) of the brain is substantially more sensitive than CT for the detection of ABE in patients with IE.12 Hence, the true incidence of ABE in left-sided IE may be significantly higher than that indicated by clinical or CT data. In keeping with this hypothesis is the fact that autopsy data have documented a very high incidence of ABE.13

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On the basis of these considerations, we initiated a prospective study to assess the incidence of both clinical stroke and SCBE among patients with left-sided IE using clinical neurological examination and brain MRI. In addition, we investigated the prognostic significance of SCBE and the risk of postoperative neurological complications in this patient population.

Methods

Patient Population
The study protocol was approved by the Institutional Review Board of the Washington Hospital Center, a tertiary referral center for patients with acute cardiac disease, including IE. Between June 2004 and March 2007, we prospectively identified all patients admitted to our institution with definite IE according to the modified Duke criteria and in whom echocardiography demonstrated that at least 1 left-sided heart valve was involved.14 All patients were invited to

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participate in the study regardless of the presence or absence of a clinically apparent embolic event. The patients or their legally authorized surrogates provided written informed consent. Patients were followed up for the duration of their hospital stay and were contacted by telephone at 30 days and 3 months.

**Echocardiography**

Transthoracic echocardiography and/or transesophageal echocardiography were performed as clinically indicated. All echocardiographic examinations were subsequently analyzed by a single experienced echocardiographer (S.A.G.) without knowledge of the clinical status of the patient. Ejection fraction was calculated with the modified Simpson rule. Valvular regurgitation was assessed semiquantitatively from 0 to 4+. Vegetation length was measured in multiple views, and the largest measurement was retained. Vegetation mobility was categorized as previously described and was considered severe if the vegetation prolapsed across the coaptation plane of the affected valve. If multiple vegetations were present, the largest vegetation was evaluated.

**Neurological Evaluation**

A detailed clinical neurological examination of each patient was performed by 1 of 2 study neurologists (R.L., M.L.) without knowledge of the results of brain or cardiac imaging. Patients were classified by the neurologist as having or not having clinical evidence of acute stroke, defined as new onset of a persistent focal neurological deficit.

**MRI Studies**

All patients without contraindication (including emergency surgery, clinical instability, unstable prosthetic valve, and presence of a pacemaker or defibrillator) underwent noncontrast brain MRI as soon as feasible after study enrollment and before any surgical intervention. Studies were performed on a clinical 1.5-T MRI system using single-shot diffusion-weighted images. T1, T2, fluid-attenuation inversion recovery, and gradient-echo images. All MRI studies were interpreted in a standard fashion by an experienced neuroradiologist (A.S.M.) without knowledge of the clinical status of the patient. The number, greatest dimension, and location of brain lesions considered to represent acute infarcts were assessed. Acute infarcts were defined as infarcts with increased signal on the diffusion-weighted images. Patients with evidence of ABE—those with at least 1 acute infarct on MRI—but no evidence of stroke on neurological examination were considered to have SCBE. MRI results were available to the treating physician.

**Statistical Analysis**

The prespecified primary end point was the percentage of patients with SCBE. Prespecified secondary end points included the overall incidence of ABE, the MRI pattern of ABE (number, size, and location) in patients with SCBE compared with patients with clinical stroke, late stroke (clinical stroke occurring after enrollment) at 30 days and 3 months, and death at 30 days and 3 months. The relationship between surgical intervention and outcomes also was assessed. Characteristics are presented as proportions or as mean±SD. Between-group comparisons were made with t tests or Fisher exact tests as appropriate. Multivariable logistic regression was used to assess the independent relationship between selected baseline factors and mortality. Baseline variables included in the analyses were age, sex, a history of diabetes mellitus, hypertension, smoking, end-stage renal disease, stroke, prior IE, ejection fraction, white blood cell count >10 000/μL, *Staphylococcus aureus* infection, coagulase-negative *Staphylococcus* infection, affected valve (mitral versus aortic), prosthetic valve IE, presence of an indwelling catheter, vegetation length >15 mm, severe vegetation mobility, extravalvular extension, clinical stroke, SCBE, and early surgery. Variables with a univariate value of \( P < 0.1 \) were included in the multivariable analyses. A value of \( P < 0.05 \) was considered to represent statistical significance.

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

**Results**

**Study Population**

During the study period, we identified 153 consecutive patients with definite IE involving 1 or both left-sided cardiac valves. Informed consent to participate in the study was obtained for 56 patients (37%), who make up the overall study cohort (Figure 1). Baseline characteristics are presented in Table 1. The mean age was 58 years (range, 29 to 85 years), and 64% were male. Thirty-six percent of patients were undergoing long-term hemodialysis. The most common causative organism was *S aureus* (n=26), followed by *Enterococcus* (n=7), *Streptococcus* (n=6), and coagulase-negative *Staphylococcus* (n=5). Culture-negative IE was present in 7 patients.

**Echocardiography**

All 56 patients were imaged with transthoracic echocardiography; 51 (91%) also underwent transesophageal echocardiography. All patients had evidence of left-sided valvular vegetation(s). The aortic valve was the only valve involved in 20 patients (36%); the mitral valve was the only valve involved in 20 patients (36%); and both mitral and aortic valves were involved in 16 patients (29%). Prosthetic valve endocarditis was present in 13 patients (23%). A vegetation >10 mm in length was present in 89% of patients. Moderate or greater valvular regurgitation was present in 45% of patients. Detailed echocardiographic results are presented in Table 2.

**Brain Embolization**

Among the 56 enrolled patients, clinical evidence of acute stroke was present in 14 patients (25%) (Figure 2). In 12 of these patients, an embolic event triggered the diagnosis of IE. Baseline clinical (Table 1) and echocardiographic (Table 2) characteristics were similar among patients with and without clinical evidence of stroke. Brain MRI was performed in 13 of 14 patients with acute stroke and revealed evidence of ABE in all 13. The single patient in this group who did not undergo brain MRI had a normal CT scan of the brain. Among the 42 patients without clinical evidence of stroke, brain
MRI was not performed in 15 patients for the following reasons: unstable prosthetic valve (n=1), clinical instability (n=3), emergency surgery (n=5), death (n=2), and patient refusal (n=4) (Figure 1). Evidence of ABE was present in 19 of 27 patients (70%) who underwent brain MRI (Figures 2 and 3). Therefore, among the cohort of 40 patients undergoing brain MRI, clinical stroke was present in 32%, SCBE was present in 48%, and the overall incidence of ABE was 80% (Figure 2). The mean diameter of the largest lesion was 25±21 mm among patients with clinical stroke (range, 2 to 66 mm) and 15±18 mm among patients with SCBE (range, 2 to 77 mm; P=0.046) and to have a baseline white blood cell count >10 000 (59% versus 13%; P=0.046). The anatomic distribution of ABE lesions in patients with clinical stroke and SCBE was generally similar, although a higher proportion of patients with clinical stroke had lesions in a subcortical location (P=0.04; Table 4).

Among the 40 patients who underwent brain MRI, 19 (48%) had IE caused by S aureus. In this subgroup, clinical stroke occurred in 7 patients (37%), and SCBE was present in 11 patients (58%). Therefore, the overall incidence of ABE was 95% among patients with S aureus IE. Among the 21 patients with other causative organisms (including culture-negative cases), the incidence of ABE was 67%, with 6 cases of clinical stroke (29%) and 8 cases of SCBE (38%). The incidence of ABE was significantly higher among patients with S aureus IE than among those with IE of any other cause (P=0.046).

Clinical Outcomes
Late clinical stroke occurred during appropriate antibiotic therapy in 2 patients. Both patients had SCBE at the time of enrollment. The first patient had mitral valve IE caused by Enterococcus and was scheduled to undergo cardiac surgery. However, the patient suffered a stroke 7 days after enrollment before surgical intervention. Surgery was subsequently performed 4 days after the stroke, and the patient survived without further neurological deterioration. The second patient, who had mitral valve IE caused by S aureus and was not scheduled for cardiac surgery because of multiple severe comorbidities, suffered a stroke 20 days after enrollment. The patient subsequently died of multiple organ failure.

Valvular surgery was performed during the index hospitalization in 25 of 56 patients (45%) at a median of 4 days (interquartile range, 2 to 8) from the time of diagnosis. No patient underwent surgery between hospital discharge and 3 months. The rate of surgical intervention was similar among patients with and without clinical stroke (43% versus 45%; P=NS). The median time from diagnosis to surgery was 6 days for patients with clinical stroke, 4.5 days for patients...
with SCBE, and 3 days for patients without ABE ($P=NS$). Among patients with clinical stroke or SCBE who underwent surgery, the mean diameter of the largest acute brain lesion was $17\pm 23$ mm (range, 4 to 77 mm). No patient suffered a clinically evident neurological complication (new brain infarction or symptomatic hemorrhagic transformation of a previous brain infarction) after surgery.

In the overall cohort, the mortality rate was 27% at 30 days and 41% at 3 months. The mortality rate was numerically but not statistically higher among patients with clinical stroke than among those without clinical stroke at 30 days (43% versus 21%; $P=0.2$) and 3 months (57% versus 36%; $P=0.2$). The mortality rate was significantly lower among patients undergoing surgery than among those not undergoing surgery at both 30 days (8% versus 42%; $P=0.006$) and 3 months (24% versus 55%; $P=0.03$). On multivariate analysis, surgery was independently associated with a reduced risk of death at 30 days (odds ratio, 0.1; 95% confidence interval, 0.03 to 0.8; $P=0.02$) and 3 months (odds ratio, 0.1; 95% confidence interval, 0.03 to 0.6; $P=0.008$). Clinical stroke was not independently associated with the risk of death at either time point.

Among the subgroup of 40 patients who underwent brain MRI, 12 patients (30%) died by 30 days and 19 patients (48%) died by 3 months. At 30 days, there were 6 deaths among the 13 patients with clinical stroke (46%), 6 deaths among the 19 patients with SCBE (32%), and 0 deaths among the 8 patients with no brain embolization (0%) ($P=0.5$ for clinical stroke versus SCBE, $P=0.08$ for any brain embolization versus no brain embolization). At 3 months, mortality was 62%, 53%, and 12%, respectively ($P=0.7$ for clinical stroke versus SCBE, $P=0.046$ for any brain embolization versus no brain embolization).

**Discussion**

In this study, we systematically assessed the incidence of ABE in left-sided IE using brain MRI imaging. Our findings suggest that the overall incidence of ABE is significantly greater than previously reported in studies on the basis of clinical findings and CT scanning and that there exists a substantial group of patients with MRI evidence of acute brain infarction in whom signs and symptoms of clinical stroke are absent. These findings, if confirmed in a larger patient population, may have important implications for the treatment of patients with left-sided IE.

Previous studies have attempted to quantify the incidence of brain embolization in left-sided IE on the basis of the clinical diagnosis of acute stroke. In recent prospective

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**Figure 2.** Clinical and MRI examination results.

**Figure 3.** Left, Transesophageal echocardiogram at the level of the midesophagus demonstrating a large vegetation on the left atrial side of the mitral valve (arrow). The patient reported no neurological symptoms, and a detailed neurological examination was normal. Right, Axial MRI of the brain using a fluid-attenuation inversion recovery sequence. The bright lesion in the left frontal cortex (arrow) represents ABE. LV indicates left ventricle.
studies, the incidence of acute stroke has ranged from 12% to 29%. In 2 of these studies, cranial CT and thoracoabdominal CT were systematically used in addition to the clinical evaluation. CT evidence of clinically silent embolization (to the brain or a peripheral site) was present in a small number of additional patients: 8% of patients in the study by Thuny and colleagues and 4.9% of patients in the study by Di Salvo and colleagues.

However, 2 lines of evidence suggested that these studies may have substantially underestimated the true prevalence of brain embolization in left-sided IE. First, CT imaging is relatively insensitive for the detection of acute stroke. Indeed, Bertorini and colleagues reported on 2 cases of IE in which cranial CT imaging was normal but MRI of the brain revealed multiple acute embolic infarcts. Second, in a study of autopsy-proven IE, evidence of ABE was present in 80% of cases. This autopsy study is significantly biased in that only patients who died and underwent pathological examination of the brain were included. However, from these reports, we hypothesized that the systematic use of brain MRI imaging in the setting of left-sided IE might detect a substantial group of patients with SCBE.

Our findings are consistent with this hypothesis. In line with previous studies, the incidence of clinical stroke in our patient population was 25%. Brain MRI confirmed the presence of ABE in each of these patients in whom it was performed. In addition, however, brain MRI detected ABE in 70% of patients in whom the clinical neurological evaluation did not reveal evidence of acute stroke. Among our cohort of 40 patients undergoing brain MRI, therefore, the overall incidence of ABE was 80%. This is 3 times greater than the estimate generated from data accumulated in multiple clinical studies over the previous 20 years but is identical to that demonstrated in the aforementioned autopsy study.

The most common causative organism in our cohort was *S. aureus*, which is consistent with findings in other recent studies. Previous research has demonstrated that infection with *S. aureus* is associated with a relatively high risk of embolic events, with a recent analysis from the International Collaboration on Endocarditis reporting a stroke incidence of 20%. Using brain MRI imaging, however, we detected ABE

### Table 3. Baseline Characteristics Among Patients Undergoing Brain MRI

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Clinical Stroke (n=13)</th>
<th>SCBE (n=19)</th>
<th>No Brain Embolization (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>57±12</td>
<td>63±13</td>
<td>61±11</td>
</tr>
<tr>
<td>Women, %</td>
<td>39</td>
<td>42</td>
<td>13</td>
</tr>
<tr>
<td>White, %</td>
<td>46</td>
<td>32</td>
<td>25</td>
</tr>
<tr>
<td>History of, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End-stage renal disease</td>
<td>46</td>
<td>37</td>
<td>38</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>31</td>
<td>37</td>
<td>50</td>
</tr>
<tr>
<td>Hypertension</td>
<td>54</td>
<td>79</td>
<td>50</td>
</tr>
<tr>
<td>Current smoking</td>
<td>15</td>
<td>21</td>
<td>38</td>
</tr>
<tr>
<td>Intravenous drug use</td>
<td>8</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>HIV infection</td>
<td>8</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>31</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Stroke</td>
<td>23</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>Heart rate, bpm</td>
<td>84±17</td>
<td>94±18</td>
<td>84±15</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>119±18</td>
<td>126±23</td>
<td>123±14</td>
</tr>
<tr>
<td>White blood cell count, 1000/μL</td>
<td>16±9</td>
<td>12±5</td>
<td>8±1</td>
</tr>
<tr>
<td>Creatinine, mg/dL</td>
<td>3.8±3.5</td>
<td>4.1±3.5</td>
<td>3.3±3.9</td>
</tr>
<tr>
<td>Affected heart valve, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic only</td>
<td>23</td>
<td>42</td>
<td>25</td>
</tr>
<tr>
<td>Mitral only</td>
<td>46</td>
<td>37</td>
<td>25</td>
</tr>
<tr>
<td>Aortic and mitral</td>
<td>31</td>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>Prosthetic</td>
<td>31</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Causative organism, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methicillin-sensitive <em>S. aureus</em></td>
<td>46</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Methicillin-resistant <em>S. aureus</em></td>
<td>8</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td><em>Any S. aureus</em></td>
<td>54</td>
<td>58</td>
<td>13</td>
</tr>
<tr>
<td>Coagulase-negative</td>
<td>8</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Staphylococcus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Staphylococcus</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><em>Any Staphylococcus</em></td>
<td>62</td>
<td>68</td>
<td>13</td>
</tr>
<tr>
<td>Streptococcus species</td>
<td>8</td>
<td>5</td>
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<tr>
<td>Enterococcus species</td>
<td>8</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Candida species</td>
<td>8</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Culture negative</td>
<td>8</td>
<td>0</td>
<td>38</td>
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</table>

### Table 4. Distribution of ABE Lesions

<table>
<thead>
<tr>
<th>Lesion Location</th>
<th>Clinical Stroke (n=13), %</th>
<th>SCBE (n=19), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortical</td>
<td>69</td>
<td>58</td>
</tr>
<tr>
<td>Subcortical</td>
<td>77</td>
<td>37</td>
</tr>
<tr>
<td>White matter</td>
<td>31</td>
<td>42</td>
</tr>
<tr>
<td>Basal ganglia</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Posterior fossa</td>
<td>54</td>
<td>26</td>
</tr>
</tbody>
</table>
in 18 of 19 patients (95%) with left-sided \textit{S aureus} IE. Even among those with other causative organisms, ABE was detected in more than two thirds of patients.

Baseline characteristics of patients with clinical stroke and those with SCBE were quite similar. In addition, the brain MRI findings in these 2 groups, including number, size, and location of acute infarcts, demonstrated substantial overlap. Therefore, it appears possible that it was the role of chance, rather than any intrinsic difference in the disease process, that resulted in the presence or absence of a detectable neurological deficit. In our small study, the mortality rate at 3 months was similar among patients with clinical stroke and with SCBE (62% and 53%, respectively), whereas it was significantly lower (12%) among patients with no MRI evidence of ABE. This suggests that the implications of ABE for the treatment of IE, particularly with regard to surgical intervention, may be independent of the clinical manifestation of the embolic event. Confirmation of this hypothesis in a larger patient cohort is required.

Most previous studies, as well as the present study, have suggested a reduction in mortality associated with early surgical intervention in patients with left-sided IE.\textsuperscript{19–24} However, some exceptions exist,\textsuperscript{4,25} and no randomized trials addressing this issue have been performed. In addition to a lack of definitive data, enthusiasm for early surgery in patients with preoperative brain embolization has been tempered by the perceived risk of postoperative intracranial hemorrhagic complications.\textsuperscript{26–28} However, a recent series of 65 consecutive operated patients with verified preoperative embolic stroke demonstrated a very low risk of postoperative neurological complications. Indeed, in that study, the only episode of postoperative intracranial hemorrhage occurred in a patient with a preoperative hemorrhagic stroke.\textsuperscript{9} Similarly, of the 16 patients with clinical stroke or SCBE who underwent early surgery in our patient cohort, none suffered a postoperative neurological event. Furthermore, our finding that a substantial percentage of patients with left-sided IE have SCBE implies that some patients selected for surgery for other indications may be currently undergoing uncomplicated valvular surgery in the presence of unsuspected ABE.

What, then, are the implications for surgical treatment when ABE, whether acute stroke or SCBE, complicates left-sided IE? Current American College of Cardiology/American Heart Association treatment guidelines provide a Class IIa recommendation for surgery of the native valve in patients with IE who present with recurrent emboli and persistent vegetations despite appropriate antibiotic therapy.\textsuperscript{2} According to the present study, however, the clinical examination appears to be insensitive to the presence of ABE. Therefore, the use of brain MRI at baseline in patients with left-sided IE should be considered to more accurately determine whether an embolic event has occurred.

Certain limitations of our study must be acknowledged. First, this was a single-center study performed at a large referral center. Enrolled patients had a high prevalence of \textit{S aureus} infection, large vegetations, and multivalve involvement. Therefore, although the rates of clinical stroke and death were similar to those of recent multicenter registries,\textsuperscript{5,10} the study population may not be representative of the wider population with IE. Second, the number of patients included was relatively small, limiting the precision of our estimates and the statistical power of our comparisons. In addition, not all qualifying patients enrolled in the study, and some enrolled patients were unable to undergo brain MRI. These factors may have introduced bias into the study. Therefore, these results should be considered preliminary and require confirmation in a larger patient population. Third, although results of brain MRI were available to the treating physicians, we were not able to determine whether these data were accessed and, if so, to what extent they may have influenced clinical decision making. This introduces a potential source of bias to our study. Fourth, this was not a randomized trial of surgical versus nonsurgical treatment of IE; therefore, the association between surgery and improved survival was likely affected by unmeasured variables. Finally, the majority of patients in this study who underwent surgery in the presence of ABE had small or moderate-sized brain infarctions. Considerable caution should be exercised with respect to cardiac surgery in patients with large infarctions, and neurological consultation is recommended.

**Conclusions**

Brain imaging with MRI reveals the presence of SCBE in a substantial proportion of patients with definite left-sided IE, particularly in those with \textit{S aureus} as the causative organism. Therefore, the overall incidence of ABE appears to be higher than that detected by previous clinical studies. The use of brain MRI to detect SCBE may provide important information with respect to clinical decision making in this patient population. Further research is required to clarify the impact of SCBE on surgical risk and long-term outcomes.

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**Disclosures**

None.

**References**


**CLINICAL PERSPECTIVE**

Infective endocarditis is a disease characterized by high morbidity and mortality. In patients with left-sided infective endocarditis, the occurrence of acute brain embolization has significant implications for prognostication and clinical decision making. In this preliminary study, we found that systematic use of magnetic resonance imaging of the brain detected the presence of subclinical brain embolization in a substantial proportion of patients in whom there was no clinical evidence of stroke. This finding was particularly prevalent among patients with *Staphylococcus aureus* as the causative organism. Patients with clinical stroke and those with subclinical brain embolization had similar baseline characteristics and survival, suggesting that clinical stroke and subclinical brain embolization may have similar clinical implications. However, patients with clinical or magnetic resonance imaging evidence of brain embolization had significantly higher mortality at 3 months than those without such findings. No patient with acute brain embolization who underwent cardiac surgery suffered a postoperative neurological complication. If these findings are confirmed in larger studies, brain magnetic resonance imaging may assume a wider role with respect to treatment decisions in patients with left-sided infective endocarditis.
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