Mechanical Discordance of the Left Atrium and Appendage
A Novel Mechanism of Stroke in Paroxysmal Atrial Fibrillation

Haider J. Warraich, MD; Maheer Gandhavadi, MD; Warren J. Manning, MD

Background and Purpose—Thromboembolism in paroxysmal atrial fibrillation (AF) has often been attributed to occult AF. We hypothesized that the surface ECG may not always reflect left atrial appendage (LAA) mechanical function.

Methods—Transesophageal echocardiographic images from 201 consecutive patients undergoing transesophageal echocardiography by a single operator were reviewed. LAA pulse wave Doppler phenotype, ECG rhythm, and mitral valve motion for rhythm of the body of the left atrium and the electronic medical record were reviewed by 3 blinded, independent observers.

Results—Of 201 patients (63.4±15 years; 61% men) undergoing transesophageal echocardiography, 15 (7.5%) demonstrated LA–LAA discordance including 7 (3.5%) with a sinus rhythm ECG/mitral valve motion and an AF LAA pulse wave Doppler phenotype. Of 24 patients with a clinical history of AF but sinus rhythm ECG, 25% demonstrated a discordant AF LAA pulse wave Doppler phenotype. Compared with concordant AF, the AF discordant group had greater CHA2DS2-VASc (vascular disease, age, sex category; P=0.008) and lower LAA ejection velocity (P=0.02).

Conclusions—A quarter of patients with paroxysmal AF demonstrate a prothrombotic AF LAA pulse wave Doppler phenotype, despite concurrent sinus rhythm ECG. These findings provide a novel explanation for ongoing thromboembolism in the paroxysmal AF population, despite apparent ECG maintenance of sinus rhythm.

Key Words: atrial fibrillation ■ echocardiography, transesophageal ■ stroke ■ thromboembolism

Atrial fibrillation (AF) is a major cause of stroke with this elevated stroke risk similar among patients with permanent, persistent, and paroxysmal AF.1 Traditionally, the mechanism for thromboembolism in patients with a history of AF yet in sinus rhythm (SR) has been ascribed to episodes of clinically silent AF that would be detected by long-term monitoring.2 In AF, the majority of left atrial (LA) thrombi involve the LA appendage (LAA). Ancillary reports have noted that the surface ECG may not always reflect underlying LAA mechanical function.3 Transesophageal echocardiography (TEE) in such patients has demonstrated an irregular, AF phenotype on LAA pulse wave Doppler (PWD), whereas the simultaneous surface ECG demonstrated SR.4 This discordance may account for thromboembolism in patients with AF despite ECG SR. In this study, we sought to assess the prevalence of LAA mechanical discordance in consecutive patients undergoing TEE at our institution.

Methods

Consecutive patients undergoing TEE by a single operator were retrospectively identified from our electronic medical records. The study was approved by the institution’s investigational review board and written informed consent was waived.

TEE ECG rhythm review was performed by an investigator (W.J.M.) blinded to TEE Doppler data. Patients were classified to be in SR or AF based on the ECG rhythm strip at the time of the TEE and anatomic M-mode of mitral valve motion (MVM). TEE images of the LAA were reviewed by a blinded independent investigator (H.J.W.). PWD flow pattern recorded from 1 cm into the mouth of the LAA at 0° and 90° was reviewed to determine LAA phenotype.5 These data were compared with the ECG/MVM data to identify cases of concordance/discordance.

Statistical analyses were performed with Stata/MP 10.0 (Stata, College Station, TX). Continuous variables were expressed as mean±SD and categorical variables as frequency or percentage. Continuous variables within 2 patient groups were compared by using independent t sample test, whereas categorical variables were compared using Fisher exact test with a statistical significance level of P≤0.05.

Results

A total of 208 consecutive TEE studies were identified during the observation period, for which TEE LAA data were available on 201 (96%) patients (63.4±15 years, 61% men). The most common indications for TEE include AF or atrial flutter (n=75), endocarditis (n=64), and source of embolism (n=24). Most strokes (n=17/38) were embolic and most (n=16/17) patients undergoing TEE to identify embolic source were without a history of AF and were in SR. No subject was <7 days postelectrophysiological procedure.

Discordance between the ECG/MVM rhythm and the LAA PWD phenotype was noted in 15 (7.5%) patient with 7 (3.5%) demonstrating AF discordance (SR on ECG/MVM and AF phenotype on LAA PWD; Figure 1), whereas 8 (4.0%)...
demonstrated SR discordance (AF ECG/MVM and SR LAA PWD; Figure 2). All patients (n=14) demonstrated concordance of the 12-lead ECG and the TEE ECG/MVM.

Comparison data for patients with AF discordance with other subtypes is presented in the Table. Of 114 (56.7%) patients with a history of AF, 24 (20.1%) were in SR on ECG/MVM at the time of TEE, including 14 (58%) who had documented SR ECG within a week of the TEE. AF discordance was noted in 25% (n=6) of these patients. Compared with the group of patients with SR concordance, the AF discordance
group had significantly higher prevalence of LAA spontaneous echo contrast, larger LAA area, longer length, lower LAA ejection velocity, and higher CHA2DS2-VASc (CHADS2, vascular disease, age, sex category; Table). LAA thrombus was noted in 6 patients, all of whom had AF concordance.

Discussion

In this retrospective study of consecutive patients undergoing TEE by 1 operator, 25% of patients with a history of AF but with SR on their surface ECG/MVM demonstrated a prothrombotic AF LAA PWD phenotype. This discordance might explain the ongoing risk of thromboembolism in patients with AF with apparently sustained SR ECG. Importantly, our study demonstrates that prolonged ECG monitoring would not detect these patients at risk. This reinforces the role of routine anticoagulation in this population and supports the routine assessment of LAA phenotype in all patients undergoing TEE independent of their ECG rhythm and clinical characteristics.

Using LAA PWD, mechanical discordance between the body of the LA and the LAA has been demonstrated postcardioversion,7 our subjects were not postcardioversion or pulmonary vein isolation.

Our study has several limitations. Our population comprises a retrospective, single center experience and heterogeneous group of patients referred for TEE. We also do not have transmitral Doppler spectra to confirm the mechanical LA function phenotype (as this is not obtained during routine TEE) and relied on ECG and MVM data for assessment of function of the body of the LA.

Conclusions

A large minority of patients with paroxysmal AF and SR ECG demonstrate a prothrombotic AF PWD LAA phenotype that is not detected on the surface ECG. These data support the use of anticoagulation in patients with AF independent of the surface ECG and serve as a novel mechanistic explanation for the ongoing risk of thromboembolism in patients with paroxysmal AF, despite apparent surface ECG rhythm control.

Acknowledgments

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Disclosures

None.

Table. Characteristics of Patients With AF Discordance Compared With Other Groups

<table>
<thead>
<tr>
<th></th>
<th>AF Discordance SR ECG/AF LAA PWD (n=7)</th>
<th>AF Concordance AF/AF (n=88)</th>
<th>SR Concordance SR/SR (n=98)</th>
<th>History of AF SR Concordance (n=18)</th>
<th>P Value SR/AF vs AF/AF</th>
<th>P Value SR/AF vs SR/SR</th>
<th>P Value SR/AF vs History of AF and SR/SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (SD), y</td>
<td>63.3 (16.5)</td>
<td>67.0 (13.0)</td>
<td>59.6 (15.8)</td>
<td>67.9 (11.9)</td>
<td>0.5</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>HR, bpm</td>
<td>69 (20)</td>
<td>96 (24)</td>
<td>80 (16)</td>
<td>77 (19)</td>
<td>0.005</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>History of AF, %</td>
<td>85.7%</td>
<td>95.5%</td>
<td>18.4%</td>
<td>100%</td>
<td>0.3</td>
<td>0.00004</td>
<td>0.1</td>
</tr>
<tr>
<td>Female, %</td>
<td>71.4%</td>
<td>40.0%</td>
<td>37.2%</td>
<td>55.5%</td>
<td>0.1</td>
<td>0.08</td>
<td>0.5</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>57.1%</td>
<td>65.6%</td>
<td>50%</td>
<td>55.5%</td>
<td>0.6</td>
<td>0.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Diabetes mellitus, %</td>
<td>28.6%</td>
<td>32.3%</td>
<td>27.9%</td>
<td>22.2%</td>
<td>0.8</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>CHF, %</td>
<td>42.9%</td>
<td>37.5%</td>
<td>17%</td>
<td>27.8%</td>
<td>0.8</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Stroke/TIA, %</td>
<td>0%</td>
<td>12.5%</td>
<td>22%</td>
<td>16.7%</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>CAD, %</td>
<td>14.3%</td>
<td>34.3%</td>
<td>22%</td>
<td>22.2%</td>
<td>0.3</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>LA SEC</td>
<td>0%</td>
<td>12.5%</td>
<td>1.2%</td>
<td>0%</td>
<td>0.3</td>
<td>0.7</td>
<td>1.0</td>
</tr>
<tr>
<td>LAA SEC</td>
<td>28.6%</td>
<td>20.8%</td>
<td>3.5%</td>
<td>11.1%</td>
<td>0.6</td>
<td>0.005</td>
<td>0.003</td>
</tr>
<tr>
<td>CHADS2</td>
<td>1.7 (1.3)</td>
<td>1.6 (1.2)</td>
<td>1.6 (1.4)</td>
<td>1.7 (1.6)</td>
<td>0.8</td>
<td>0.85</td>
<td>0.9</td>
</tr>
<tr>
<td>CHA2DS2-VASc</td>
<td>3.1 (2.2)</td>
<td>1.6 (1.3)</td>
<td>3.0 (1.9)</td>
<td>3.2 (2.0)</td>
<td>0.008</td>
<td>0.55</td>
<td>0.9</td>
</tr>
<tr>
<td>LAA area 0°, cm²</td>
<td>7.2 (3.6)</td>
<td>5.6 (2.9)</td>
<td>4.6 (2.4)</td>
<td>4.1 (2.6)</td>
<td>0.09</td>
<td>0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>LAA area 90°, cm²</td>
<td>4.7 (1.8)</td>
<td>5.6 (2.5)</td>
<td>4.1 (2.0)</td>
<td>4.6 (2.0)</td>
<td>0.2</td>
<td>0.26</td>
<td>0.8</td>
</tr>
<tr>
<td>LAA length 0°, cm</td>
<td>4.5 (1.4)</td>
<td>4.1 (1.2)</td>
<td>3.6 (1.1)</td>
<td>3.4 (1.2)</td>
<td>0.3</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>LAA length 90°, cm</td>
<td>3.5 (0.9)</td>
<td>4.1 (1.1)</td>
<td>3.5 (0.9)</td>
<td>3.6 (0.8)</td>
<td>0.09</td>
<td>0.85</td>
<td>0.8</td>
</tr>
<tr>
<td>LAA ejection velocity 0°, m/s</td>
<td>0.22 (0.08)</td>
<td>0.34 (0.19)</td>
<td>0.56 (0.25)</td>
<td>0.37 (0.16)</td>
<td>0.02</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>LAA ejection velocity 90°, m/s</td>
<td>0.25 (0.10)</td>
<td>0.37 (0.23)</td>
<td>0.52 (0.26)</td>
<td>0.35 (0.13)</td>
<td>0.05</td>
<td>0.0001</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Mean (SD). AF indicates atrial fibrillation; CAD, coronary artery disease; CHADS2, congestive heart failure, hypertension, age, diabetes, prior stroke/TIA; CHA2DS2-VASc, CHADS2, vascular disease, age, sex category; CHF, congestive heart failure; HR, heart rate; LA, left atrium; LAA, left atrial appendage; PWD, pulse wave Doppler; SEC, spontaneous echo contrast; SR, sinus rhythm; and TIA, transient ischemic attack.
References
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